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Meeting the Nation's Needs for Biomedical and Behavioral Scientists

SUMMARY OF THE 1993 PUBLIC HEARING

Laura Lathrop and Pamela Ebert Flattau, editors

Committee on National Needs for
Biomedical and Behavioral Research Personnel
Studies and Surveys Unit
Office of Scientific and Engineering Personnel
National Research Council

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NATIONAL RESEARCH COUNCIL OFFICE OF SCIENTIFIC AND ENGINEERING PERSONNEL STUDIES AND SURVEYS UNIT

COMMITTEE ON NATIONAL NEEDS FOR BIOMEDICAL AND BEHAVIORAL RESEARCH PERSONNEL

* Resigned March 1994.

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PREFACE

In 1994 we mark the twentieth anniversary of the National Research Act of 1974 (P.L. 93-348) which established the National Research Service Awards (NRSA) program. In its 20 years of operation, the NRSA program has made it possible for many thousands of talented individuals in the basic biomedical, behavioral, and clinical sciences to sharpen their research skills and to apply those skills to topics of special concern to the nation, such as aging, hypertension, the genetic basis of disease, acquired immune deficiency syndrome (AIDS), cancer, environmental toxicology, nutrition and health, and substance abuse.

The NRSA legislation of 1974 directed the Secretary of Health and Human Services (as the department is known today) to arrange for a continuing study of "national needs" for biomedical and behavioral scientists and to request that the National Academy of Sciences conduct that study. In 1992, the National Research Council (NRC) -- the operating arm of the National Academy of Sciences, the Institute of Medicine, and the National Academy of Engineering -agreed to undertake the tenth in a series of NRC studies of the NRSA program. In December 1992, the NRC appointed the Committee on National Needs for Biomedical and Behavioral Research Personnel, which we have been privileged to chair. It was our committee's task to establish the nation's overall need for biomedical and behavioral scientists, the subject areas in which such personnel are needed, and the number of such personnel in each area for 1994 and beyond. The results of our deliberations may be found in a separate volume published by the National Academy Press, *Meeting the Nation's Needs for Biomedical and Behavioral Scientists* (Washington, D.C., 1994).

An important activity during the study process was the Public Hearing we convened on May 3, 1993, at the National Academy of Sciences Auditorium in Washington, D.C. Many training grant directors, students, and representatives of professional societies generously donated their time by first responding to our request for suggestions about ways to improve the NRSA program, and next by participating in the public hearing. This report summarizes the main issues we identified from the numerous presentations at the oneday meeting and provides a record of the testimony submitted by the 35 speakers. This report does not represent an endorsement of these suggestions by the committee or the National Research Council. Rather, we offer these ideas for further consideration by the research and policy communities.

The committee would especially like to thank Walter Schaffer, Research Training and Research Resources Officer at the National Institutes of Health for contributing to the design of the public hearing and to Pamela Ebert Flattau, Director of the NRC/OSEP Studies and Surveys Unit who effectively organized the meeting. Laura Lathrop, project consultant, assisted us in organizing the material that is the subject of this report and, together with Dr. Flattau edited this report. Patricia Takach, our administrative assistant, skillfully coordinated the production of this volume which involved working with speakers and with the committee. To all these individuals, we express our gratitude for their efforts.

IRA J. HIRSH

JOHN D. STOBO, Co-Chairs

Committee on National Needs for Biomedical and Behavioral Research Personnel

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SUMMARY OF ISSUES AND SUGGESTIONS FROM SPEAKERS

On May 3, 1993, the National Research Council's (NRC) Committee on National Needs for Biomedical and Behavioral Research Personnel convened a public hearing to gather the views of colleagues on the future direction of the National Research Service Awards (NRSA) program. In preparation for the hearing, the committee formulated a set of questions to be addressed by respondents and consulted with the staff of the National Institutes of Health in compiling a list of individuals and organizations to whom a letter soliciting a response to those questions could be sent. (See Appendix A.) A letter posing the following four questions was sent to over 1,000 individuals:

- What is the most significant challenge we face today in the United States in maintaining an adequate supply of qualified scientists to sustain and advance health research?
- What improvements might be made in the National Research Service Awards (NRSA) program to assure a continuing supply of skilled investigators in the biomedical and behavioral sciences in the coming years?
- What steps might be taken to improve the effectiveness of the NRSA program in recruiting women and minorities into scientific careers?
- What features of the NRSA training grant might be strengthened to assure the maintenance of high quality research training environments?

Respondents also addressed the need for biomedical and behavioral research personnel in nontraditional settings, such as industry. Approximately 200 responses were received (Appendix B) and guided the selection of issues that follows. In addition, from these 200 respondents, 35 individuals were invited to participate in a one-day public hearing convened on May 3rd in Washington, D.C. (See Appendix C.)

At a subsequent meeting of the committee, issues frequently mentioned by hearing participants were identified and discussed, including:

- the need for realistic assessments of supply and demand;
- the matter of attracting young people to careers in science;
- the role of stable research funding in facilitating scientific careers;
- the need to raise NRSA stipends;
- reasons to expand the Medical Science Training Program;
- the role of NRSA support for women in science;
- the role of NRSA support in recruiting underrepresented minorities into science and technology careers; and
- some ways to increase the effectiveness of the NRSA program.

This report summarizes the views of speakers at the 1993 public hearing organized around those themes.

ISSUE 1 THE NEED FOR REALISTIC ASSESSMENTS OF SUPPLY AND DEMAND[1]

Many speakers observed that maintaining an adequate supply of qualified scientists to sustain and advance health research is a significant challenge. The challenge arises from the unevenness of supply given demand, and from the lack of community consensus on what constitutes an "adequate supply."

The need for research personnel varies, furthermore, from field to field. In some specialty areas there are more qualified candidates than faculty positions. In other specialties and subspecialties, such as nursing, oral health and prevention research or microbial physiology, not enough scientists are trained to fill available positions in academia and industry.

Numerous factors contribute to the shortage of trained researchers. Some identified by public hearing participants include the following:

- The scope of the research base is expanding in some fields. For example, as the population ages, there are new demands on health care services which in turn requires the development of information about the effective delivery of services to older citizens.
- Career opportunities in industry are increasing, with applications not only in medicine but also in agriculture, environmental remediation, and related areas.
- A large cadre of researchers is approaching retirement age.
- The time needed for training a researcher is longer than almost all other types of professional training, averaging 5 to 6 years for the Ph.D. and 3 to 4 years for postdoctoral studies.
- Some areas of research training, such as microbial physiology, have been neglected, while others, such as molecular biology and genetics, have grown.

Perceptions of the adequacy of the applicant pool also vary, according to speakers. In some fields the pool appears to be sufficient while in others it is diminishing. Those who felt the pool was shrinking related the phenomenon to problems in the career path, noting that too few Americans graduate from high school with an adequate grounding in science or mathematics to pursue a career in research. Some speakers felt that information is also needed about the character of the applicant pool. For example, what is the current number of individuals available for training or the number of trainees who actually choose career paths other than research?

A number of speakers noted that there is a general lack of physician-scientists. However, the need varies across subspecialties. In some areas, the pool of physician-scientist candidates is shrinking. In others, the pool may be adequate, but the loss of candidates to other career tracks is a problem. In some fields, the demand is far greater than the supply.

The unpredictability of R&D funding is a significant factor in balancing the supply and demand of research personnel, according to a number of speakers. Another issue affecting supply arising from the lack of sufficient and/or stable resources is the diversion of scientists' time and energy from research to grant application writing.

Suggestions from Speakers

Ongoing Assessments

A number of speakers emphasized the need for ongoing evaluation of "national needs" in the face of these various factors affecting "supply" and "demand." Such assessments should include examination subject areas in which personnel "needs" exist, whether training programs are meeting those needs, the current status of training of personnel, and areas in which training should be intensified. Speakers also suggested that realistic assessments of personnel needs ought to include a look at:

[1] Material in this section drawn from testimony by: D. Brautigan, G. Cassell, P. Cozzi, J. Fielding, S. Gerbi, B. Giddings, R. Grand, A. Jacox, H. Kazemi, G. Kimmich, V. LiCata, D. Linzer, T. Malone, B. Marshall, P. Morahan, S. Persons, C. Pings, J. Pohl, D. Purpura, I. Sandler, P. Shank, J. Sheridan and J. McCormick, and H. Slavkin. See Appendix D .

- employment conditions for working scientists,
- the ability of scientists to move between academic and industrial employment,
- attention to the educational and employment experiences of women and minorities,
- retraining opportunities for mid-career scientists and the types of retraining programs that could be pursued on a part-time basis, and
- innovative educational and employment programs between industry and academia.

The Applicant Pool

Suggestions for improving the applicant pool included:

- maintaining and expanding the availability of traineeships/fellowships,
- identifying predictors of success in research, and
- opening NRSA training to foreign nationals.

Physician Scientists

The importance of clinical research to national goals was emphasized by a number of speakers. Many suggested that high priority be placed by the NRSA program to meet the needs for these investigators.

Research Support

Numerous participants commented on the need for basic research in the biomedical and behavioral sciences.

Other suggestions for stabilizing the research base included the need to foster communication within the community of scholars who can act as a support group and network with each other, especially through electronic networks.

ISSUE 2 ATTRACTING YOUNG PEOPLE TO CAREERS IN SCIENCE[2]

Young people are attracted to science for the excitement and challenge as well as the opportunity to build a stable and rewarding career. Yet, the loss of potential scientists occurs at every stage of the education path, from early childhood education through graduate school. According to some of the speakers, students think “science is neat,” but are discouraged by the long period of training. Science also suffers from an image of being boring, incomprehensible, or “not cool” and scientists are often seen as being uncaring and out-of-touch with society.

Other problems people encounter along the scientific career path include:

- their early education in science and mathematics is inadequate: teachers are often poorly informed about these subjects and textbooks are outdated; and
- there is a lack of a realistic understanding of the job of a scientist: basic research requires enormous dedication, long hours, frustration, and sheer hard work. Students see mentors struggling to maintain a career in the face of inadequate funding and may decide a research career is not for them.

Suggestions from Speakers

Speakers offered a number of interesting suggestions for taking more effective action in recruiting students into science careers.

[2] Material in this section drawn from testimony by: J. Fielding, B. Giddings, G. Kimmich, V. LiCata, D. Linzer, C. Lumeng, T. Malone , P. Morahan, P. Shank, H. Silber, H. Slavkin, O. Weisz, and M. Yamaguchi. See Appendix D .

Image

- Improve the image of the scientist as a person through the use of media such as children's TV programs.

Teaching/Learning

- Focus attention on the education of children because they are a large undeveloped resource. Increase and nurture their level of interest in science and encourage their desires to explore questions about nature, starting in elementary school.
- Make science attractive by inviting people in science to visit schools; use team discovery projects to foster an interest in science; develop science fairs, clubs, camps, and links with industry.
- Improve science education at elementary and grade school levels by providing better training and continuous retraining for teachers of science in grades K-12 and by having university faculty interact with elementary, middle school and high school teachers.
- Teach science and mathematics effectively beginning at age 6. The importance of fostering basic critical thinking skills was emphasized.
- Develop mentoring programs especially in high school and in college. A good mentor will critique work, teach new techniques, maintain high ethical standards, and encourage a young career.
- At the college level, take freshman science students into an undergraduate research group to motivate them and get them involved early.
- Provide well-paid summer research fellowships for undergraduates. Include salary, traveling expenses, and a small stipend.

Collaborative Approaches

- Coordinate the teaching of science by exposing students to science in a variety of employment settings. Teachers should lay the initial foundation of information for the children. Industry and academia should provide opportunities for children to see that further pursuit of studies in science can lead to interesting careers.

Dissemination of Information

- Develop and disseminate information, e.g., a directory of available science and mathematics scholarships.
- Develop a strong portfolio of diverse career options: include academic and industrial research, technology, teaching, and combinations of these.
- Develop widely visible materials on the spectrum of full time and part time career opportunities available for scientists and disseminate these options to undergraduate and graduate students.

ISSUE 3 STABLE RESEARCH FUNDING[3]

A number of speakers observed that attempts were made in the past to reduce funding to the National Institutes of Health (NIH). While these proposed cuts were consistently rejected by Congress, the annual budget battle inevitably created a great deal of uncertainty within the biomedical research community. Even when proposed cuts were rejected and increased funding was provided, there was still a significant shortfall in dollars needed to fund many qualified grant applications. Today, the NIH funds approximately 18 percent of its approved grant applications. Even those grants that are funded receive significantly less than the

[3] Material in this section drawn from testimony by: D. Brautigan, G. Cassell, P. Cozzi, E. Jones, S. Gerbi, B. Giddings, R. Grand, A. Jacox, H. Kazemi, G. Kimmich, T. Krulwich, V. LiCata, D. Linzer, B. Marshall, P. McCloskey, T. Meyer, P. Morahan, S. Persons, C. Pings, J. Pohl, D. Purpura, I. Sandler, P. Shank, J. Sheridan and J. McCormick, H. Slavkin and O. Weisz. See Appendix D .

dollar amount requested and approved by the NIH Study Sections. This scenario has resulted in individual investigators applying for multiple grants on a variety of funding cycles, constantly wondering if the dollars will be there tomorrow for the research that is started today.

Grants are vital to carry out research. Without improvement in long-term funding, we run the risk of losing the scientific primacy of the United States and, in the long run, our biomedical research endeavor will become totally commercialized. Science for the sake of science will no longer be performed by anyone, according to the speakers.

Perceptions of insufficient resources for research discourage highly capable people from entering a research-oriented career track and encourage some who have already entered to change career directions.

Other speakers noted that the uncertainty of renewals and resulting time spent revising applications interfere with the productivity of established research programs. In addition, many scientists are uncomfortable about competing with colleagues for limited resources. Moreover, the combination of constraints in funding and opportunities for success in rapidly changing fields conspire to make new investigators conservative. They tend to relate proposals to prior work at the parent postdoctoral lab because it is too risky to propose more individual and novel projects. This hurts the whole research enterprise.

Suggestions from Speakers

- Stabilize biomedical and behavioral research funding.
- Provide sufficient funds for NRSA fellows to conduct pilot studies to develop their own initial programs of research as a bridge into a scientific career.
- Increase funding for seminars and research retreats for trainees. This would provide a relatively inexpensive exposure to real research application/support issues.
- Fund faculty to work with postdoctoral fellows and provide mentor salaries. The incentive to supervise training can make a critical difference in establishing new research and training programs, including interdisciplinary ones.

ISSUE 4 NRSA STIPENDS AND STIPEND PACKAGES[4]

While long-range prospects supply the most compelling reasons for pursuing a research career, more immediate incentives, such as stipends, play an indisputable role. With that in mind, speakers commented that it is disturbing to note that stipend levels for trainees in the NRSA program have remained unchanged since 1991.

The stipends for predoctoral trainees and postdoctoral fellows are inadequate and insufficient to cover the cost of living. Awardees are supported below the poverty line and require supplementation to stipends to meet basic needs. Many trainees in all programs must work to supplement their income, thus reducing time and energy available for studying.

NRSA stipends have not kept pace with salaries of M.D.s in practice or Ph.D.s recruited into industry. Nor are NRSA stipends commensurate with those of some other programs. With tuition and stipend payments assured throughout their schooling, students in the Medical Scientist Training Program, for example, are clearly more insulated from financial pressures than other trainees. By graduation, their educational debt averages $23,000, while that of the typical graduating M.D. is $56,000, more than twice as much.

Most universities augment NRSA stipends, which requires them to divert resources from other university functions. When universities are unable to augment stipends, trainees are forced to take out loans or work to meet their living expenses. Loans increase already considerable debt burdens incurred in undergraduate education, and working to earn a living income draws students away from their academic program, extending their time to degree. As a nation,

[4] Material in the section drawn from testimony by: D. Brautigan, G. Cassell, S. Gerbi, B. Giddings, R. Grand, A. Jacox, G. Kimmich, D. Linzer, T. Malone, S. Persons, C. Pings, J. Pohl, D. Purpura, I. Sandler, J. Sheridan and J. McCormick, and H. Slavkin. See Appendix D .

we will attract our "best and the brightest" only by offering stipends that show them that we value a research career as highly as we value other types of professional employment.

Suggestions From Speakers

Addressing stipend inequities should be a high priority for the NRSA research training program. Speakers specifically suggested attention to these issues:

Increase the Stipend

- Predoctoral stipends should be increased into a range that is competitive with stipends paid by other state and federal agencies, e.g., most state university stipends start at $11,000 and NSF currently pays $14,000, and the U.S. Department of Education now pays $14,000 annually.
- Stipend levels should be increased for individuals seeking careers in clinical research.
- Stipend increases should reflect inflationary changes, and the training budget should be sufficient to allow cost-of-living adjustments to be made annually and computed into each training grant's continuation base.
- Other mechanisms should be established such as private sector partnerships to ensure that stipends reach competitive levels.

Additional Support

- Change the policy preventing supplementation of NRSA trainee support with funds from a federal grant.
- Money should also be added to NRSA support for laboratory training expenses such as research supplies and equipment.

Innovative Program Support

- Institute a one year research support program in which students receive: credit for research performed, living expenses, support for interest due on loans, a modest amount for lab fees.

ISSUE 5 EXPANDING THE MEDICAL SCIENTIST TRAINING PROGRAM[5]

The Medical Scientist Training Program (MSTP) awards both the M.D. and the Ph.D. degrees after a rigorous course of study. This is recognized as the most successful NIH training program, according to many speakers. A 1992 study of graduates of the Johns Hopkins University's M.D./Ph.D. program found that all of those who had completed their training were actively involved in research at that time: 81 percent in academia, 14 percent at research institutes, and 5 percent in the biotechnology industry.

Some speakers expressed concern, however, that the program could do more to encourage its trainees to pursue problems in human disease--a research area for which they should be uniquely qualified, but, by some indications, are disinclined to pursue. While the goal of the MSTP program is to train both basic and clinical researchers, Washington University's Carl Frieden and Barbara Fox reported in 1991 that 83 percent of their MSTP graduates were engaged in full-time basic research. Similarly, in a 1990 analysis of the research publications of a sample of MSTP graduates, Edward Ahrens found that 75 percent of their work focused on nonclinical research. The findings of Frieden, Fox, and Ahrens suggest that at least some portion of MSTP trainees should be considered as pursuing basic science careers rather than clinical science careers. If further study confirms that MSTP graduates gravitate toward narrow areas of research, an effort should be made to broaden training.

Suggestions From Speakers

The following suggestions for expanding the MSTP program were offered by speakers:

[5] Material in this section drawn from testimony by: D. Brautigan, S. Gerbi, C. Lumeng, and T. Malone. See Appendix D .

- Raise the total number of MSTP trainees to 1,000 by adding 250 slots.
- Examine the cost effectiveness of the program relative to other forms of training support.

ISSUE 6 WOMEN IN RESEARCH[6]

The number of women in the life sciences has increased dramatically in the last 20 years. Over 40 percent of the Ph.D.s produced in the life sciences are women. At this stage they are not really underrepresented. The difficulty occurs later when employment opportunities are limited by geographical considerations or by family obligations.

Some say recruiting women into science is a problem, a symptom of our society and the way we approach science. Others say recruitment is not the problem, but professional advancement is the problem. The number of women who successfully graduate into independent positions in science and are promoted into the higher ranks is small.

Suggestions From Speakers

Although some speakers considered the problems of recruitment and professional advancement to be beyond the purview of the NRSA program, some offered suggestions related to outreach and incentives, administrative and program flexibility, and mentoring and support groups through NRSA support.

Outreach and Incentives

- Reconsider NRSA's support structure to increase options and access to scientific careers by providing incentives for completing studies early; increasing the length of time allowed for support on NRSA awards; and allowing more employment hours than at present.
- Improve access in geographic terms, e.g., programs in nursing have limited locations and they need to be more accessible to increase participation of women in advanced training in this area.
- Provide small grants for undergraduate research by women.
- Give attention to M.D./Ph.D. programs as a strategy to attract female scientists into research careers. These fellowships may be more attractive than those that are limited to graduate and postgraduate training.
- Use innovative training programs that guarantee placement on completion of the course.

Flexibility

- Increase flexibility in NRSA programs by developing formal policies for family leave and part-time training. Develop ways to help with child care support by provision of government subsidies or grants from private foundations for child care.
- Target funds to develop mid-career mechanisms for re-entry to a career track. NRSA should specifically encourage applications from women who have taken time off in early or mid-career to raise children. Individual fellowship support for these women would be especially effective in providing them with opportunities .
- Create new mechanisms to make postdoc opportunities compatible with lifestyle issues, e.g., a program for younger faculty similar to NSF's Women Scholars Program of several years ago.

Support Systems

Establish a mentor system through the NRSA program. Augment existing individual project grants so that principal investigators take on

[6] Material in this section drawn from testimony by: D. Brautigan, G. Cassell, S. Gerbi, A. Jacox, A. Kraut, V. LiCata, D. Linzer, T. Malone, B. Marshall, P. McCloskey, S. Persons, J. Pohl, D. Purpura, J. Sheridan and J. McCormick, H. Silber, and O. Weisz. See Appendix D .

the dual role of recruiter and mentor of young scientists.

- Establish support groups that are visible and integral parts of the training environment.

Organizational Linkages

- Link training with the private sector, e.g., private sector intern programs, at various stages in the educational process including predoctoral NRSA training.

ISSUE 7 MINORITIES IN RESEARCH[7]

African-Americans, Hispanics, and Native Americans account for no more than a couple of percent of all Ph.D.s in the life sciences. These numbers have been constant for two decades, and show little sign of improvement.

Most under-represented minorities with a desire to work in the life sciences are not entering Ph.D. programs. Instead, they are going to medical school. The Association of Medical Colleges (AAMC) reported that in 1991, 918 black Americans, 46 Native Americans, and 362 Hispanic Americans graduated from medical school. By comparison, according to the National Science Foundation, only 6 black Americans received Ph.D.s in biochemistry in 1991, and only 44 Ph.D.s were awarded to black Americans in all the biological sciences combined. Likewise, 10 Native Americans and 78 Hispanic Americans received a Ph.D. in the life sciences. Thus, there were 10 M.D.s for every Ph.D. earned by members of these groups.

Much has been done to try to improve minority recruitment. Predoctoral training grants require a proactive stance on the part of the schools they fund; the Minority Access to Research Careers Program (MARC) tries to support the pool from which minority applicants will come; recent policy changes permit supplements for minority students supported by research grants; and there is a new program of individual minority predoctoral fellowships. Despite these efforts, many of the same forces drive both minority and majority students: the best students often choose an M.D. over a Ph.D. because it offers a more secure job at a better salary.

Many universities have used the MARC program to identify promising undergraduates and provide them with summer research internships and related activities to interest them in and prepare them for graduate study. The quality of the research program and the extent of faculty mentoring are major determinants in the success of institutional programs, and these attributes should continue to play a determining role in awarding grants in any expanded program.

Some problems identified by speakers that affect minorities making careers of research in health fields include:

- Recruiting underrepresented minorities into science is a problem. It is a symptom and reflection of our society and the way we approach science (See Issue 2: Attracting Young People to Science Careers). Some feel that the pool of available applicants is so small that recruitment efforts are simply “reshuffling the deck.”
- The number of trainees funded on the individual minority predoctoral fellowship program is declining due to the lack of special budget appropriations.
- In some fields, such as microbiology and anesthesiology, minority representation is very poor.
- The structure of the NRSA predoctoral awards is restrictive, underfunded, and fails to recognize the diversity of highly qualified minority applicants (Report of American Society for Microbiology Committee on the Status of Minority Microbiologists).
- The NRSA award criteria are heavily weighted toward student performance on standardized examinations.

[7] Material in this section drawn from testimony by: D. Brautigan, G. Cassell, S. Gerbi, L. Goldman, R. Grand, J. Jones, A. Jacox, H. Kazemi, T. Krulwich, V. LiCata, D. Linzer, C. Lumeng, T. Malone, B. Marshall, P. McCloskey, T. Meyer, S. Persons, C. Pings, D. Purpura, P. Shank, J. Sheridan and J. McCormick, H. Silber, H. Slavkin, and O. Weisz. See Appendix D .

In addition to issues of recruiting and retaining ethnic and racial minorities, there are similar issues involving lesbian and gay people. Many lesbian and gay scientists choose not to disclose their orientation for fear of harassment, limited choice of employment location, or dismissal. Others choose not to focus on lesbian and gay issues in their research for fear their careers may suffer.

Suggestions from Speakers

A number of suggestions were offered for increasing the participation of minority group members through the NRSA program.

Outreach

- Target specific numbers of NRSA awards for early intervention programs for minority groups.
- Train NRSA program directors to be more effective in minority outreach efforts.
- Require (and fund) the principal investigator of each institutional NRSA to attend one meeting during every five-year cycle specifically to recruit minority medical students or house staff into research careers.
- Promote the MSTP program to minority undergraduates as a way of solving two problems at one time: minority students could attain their medical degrees and would also be trained to do research. The MSTP program could also be promoted to minority students after they have entered medical school, and this would be an especially promising way to capture them for careers in research.

Financial

- Set aside a fixed percentage of training funds for minority students to encourage appointment to NRSA programs.
- Share the funding load with other federal funding agencies or federally funded university training programs.
- Increase flexibility of incentives for principal investigators to hire minority graduate and undergraduate students.

Early Research

- Expose undergraduates to research early in their educational experience through creative course work and independent study. Encourage such experience by providing small grants or NRSA awards for undergraduate research.
- Provide well-paid summer research fellowships for undergraduates that include salary, traveling expenses, and a small stipend.

Expanding Programs

- Encourage, support, and expand successful programs, e.g., MARC Program, which has proven to be highly effective in drawing talented minority students into careers in biomedical research.
- Expand programs such as special grants for minority students.

Organizational Linkages

- Develop linkages between minority institutions, organizations, and research intensive institutions.
- Link training with the private sector, e.g., an NRSA minority intern program.

Administration

- NIH institutes should rigorously review summaries of minority recruitment and retention, and enforce requirements under NRSA provisions.
- Evaluate programs such as the MARC and Minority Biomedical Research Support (MBRS).
- Use innovative training programs that

guarantee placement on completion of the course.

Support Systems

- Develop special support mechanisms through the NRSA program to help retain even the best minority students.
- Provide role models during training. Sponsor seminars for minority scientists. Seminars might include discussions on ethics, discussions with faculty and students on the apprenticeship system of research training and the responsibilities of mentors to all trainees.
- Provide mentors who give encouragement and guidance at critical times. Mentoring may include the more formalized participation of research faculty from research-intensive institutions as mentors to young faculty/ students at smaller, more teaching-oriented institutions with funded minority programs.

With respect to lesbian and gay issues, these too reflect our society and are basically social problems. Legislation of a civil rights law for lesbian and gay people and legal recognition of their relationships should be pursued. There is a pressing need for researchers knowledgeable about lesbian and gay issues, e.g., AIDS research. Funds should be earmarked for lesbian and gay studies.

ISSUE 8 INCREASING THE EFFECTIVENESS OF THE NRSA PROGRAM[8]

Institutional training grants tend to improve the quality of the entire predoctoral program in a department for both trainees and non-trainees. They induce an interdisciplinary focus and provide the broad training necessary to meet changing manpower needs. Training grants provide the leverage that would be impossible on individual research grants to influence programmatic aspects, e.g., influence schools to provide training on ethical issues and be proactive in minority recruitment.

Various opportunities are emerging for research scientists in industry and other new settings. These emerging research opportunities make it increasingly important for trainees to have broad-based scientific training. NRSA programs must be designed to train the full range of biomedical and healthcare scientists needed for the future.

The ideal preparation for the future of biomedical and behavioral research personnel is to equip people with thinking skills and understanding of the basic forces and structures of life to address changing challenges in a rapidly changing environment. To train a scientist in a “targeted” way, with an eye toward a specific (applied) research setting, is to severely limit that scientist’s potential. It limits the ability to change with the rapid changes in such applied fields as biotechnology.

The biggest problem with the research training environment today, according to many speakers, is related to underfunding and the fierce competition for scarce resources. Mentors must spend less time in the laboratory directly supervising trainees and more time writing grant applications. This also results in less time spent on lecture preparation as well as fewer seminars and advanced courses being offered at most institutions. In addition, because the laboratory work of trainees is directly linked to external funding sources, there is more pressure for trainees to produce results at a faster rate and, in many cases, to publish prematurely.

Most NRSA fellows are based at only a few academic institutions, with the result that postdoctoral trainees become concentrated in labs with many other postdoctoral students where they do not receive much attention and have limited interaction with faculty.

Usually a predoctoral traineeship is in the first two years of graduate school when the student is taking courses and research rotations. Research grant support should be provided when the student is more advanced and time is focused on research rather than on course work.

[8] Material in this section drawn from testimony by: D.Brautigan, G. Cassell, P. Cozzi, S. Gerbi, L. Goldman, J. Jones, H. Kazemi, A. Kraut, T. Krulwich, V. LiCata, D. Linzer, T. Malone, B. Marshall, P. Morahan, S. Persons, C.Pings, J. Pohl, D. Purpura, P. Shank and H. Slavkin. See Appendix D .

The amount of paperwork involved in applying for the NRSA fellowship far exceeds that required for any other postdoctoral fellowship.

Suggestions From Speakers

Numerous suggestions were offered, which included treatment of the following topics:

Individual Awards

- Examine the issue of whether a cap should be placed on the number of individual NRSA fellows per lab.

Access

- Increase the flexibility and access to programs throughout the country and in a wide variety of institutions.

Curriculum

- Train Ph.D. scientists who know basic science and have awareness of clinical problems and an ability to work with physicians as well as basic "wet lab" skills. Include training in patient-oriented outcomes research and research at the interface between laboratory discoveries and clinical applications.
- Provide a broad-based and interdisciplinary curriculum, including a solid background in general biochemistry and molecular biology rather than a focused program such as biotechnology which can be obsolete before the degree is awarded.
- Emphasize interdisciplinary approaches that pair the biomedical sciences with chemistry, engineering, and computer science as well as patient-oriented clinical research, clinical epidemiology, biostatistics, outcomes research, and health services research. Examples of interdisciplinary researchers are demographers and sociologists trained in aging research; epidemiologists with a background in economics; psychologists interacting with engineers to help frail older adults live independently at home; and neuroscientists, who consistently utilize knowledge and techniques in several disciplines including neuroanatomy, physiology, neurochemistry, and molecular genetics. Periodically establish new training grants in cross-disciplinary interfaces.
- Both pre- and postdoctoral students should complete courses in experimental design, statistical analysis, grant writing, oral scientific communications, and public science policy. They should also be exposed to grant accounting, management, and a minimal amount of teaching experience.

Collaboration

- Develop team research and multi-university relationships.
- Establish training programs that are jointly sponsored by academic institutions and industry.

Review

- Use the NRSA annual progress report as a basis for evaluating productivity and continued financial support.
- Develop criteria for measuring the effectiveness of mentors and training programs.

Administration

- Streamline guidelines. NIH and subspecialty boards should come to a better understanding of their aims so that together they can provide a meaningful national program for training biomedical researchers who can participate in both clinical and basic research.
- Streamline the paperwork involved in applying for a fellowship.
- Maintain the non-trainee expenses allocated to predoctoral training grants for such activities as a graduate program seminar series and research day retreats.

- Have yearly national meetings of individual NRSA recipients.
- Restructure NRSA programs to encourage a full or modified Ph.D. training program for physicians.

This brief summary captures only a few elements of the rich set of ideas submitted by speakers at the 1993 public hearing. Readers are encouraged to review the individual testimony in Appendix D for a fuller view of specific suggestions.

APPENDIXES

APPENDIX A

LETTER OF SOLICITATION

March 16, 1993

Judson Sheridan
Vice Provost for Research
and Dean of the Graduate School
University of Missouri
Columbia,Missouri

Dear Dr. Sheridan:

A continuing goal of our national research effort is to sustain the quality of biomedical and behavioral research. To achieve this goal we must maintain research training environments of high quality and sufficient stability to assure the future availability of skilled research personnel.

The National Research Service Awards Act of 1974 established a Federal program of predoctoral and postdoctoral training support to meet national needs for biomedical and behavioral scientists. At the same time, the Act requested that the National Academy of Sciences undertake a continuing study of personnel needs in this area and that they report on a regular basis to the U.S. Congress, the National Institutes of Health, and related agencies regarding future training needs in this area.

The National Research Council, the operating arm of the National Academy of Sciences, recently established the Committee on National Needs for Biomedical and Behavioral Research Personnel which we are privileged to chair. The committee recently met for the first time and concluded that it would be useful to solicit the views of our colleagues in the scientific and educational communities as we formulate our recommendations for the future direction of the NRSA program.

To that end, we have arranged to convene a Public Hearing on May 3, 1993, at the NAS Auditorium, 2101 Constitution Avenue, NW, in Washington, D.C. The one-day meeting will begin at 8:00 a.m. and conclude at 6:00 p.m. During the hearing, 35 individuals will provide brief testimony on research training needs in various component fields at the invitation of the Committee.

There will be opportunities for other audience members to offer comments during periods of “Open Discussion” scheduled throughout the day. Testimony will address research training in the biomedical and behavioral sciences, the clinical sciences, nursing research, and health services research.

Owing to your longstanding interest in research training issues in the biomedical and behavioral sciences, we would like to invite you to submit a two or three-page letter no later than March 29, indicating your preliminary thoughts in reaction to these four questions:

1. What is the most significant challenge we face today in the United States for maintaining an adequate supply of qualified scientists to sustain and advance health research?
2. What improvements might be made in the National Research Service Awards program to assure a continuing supply of skilled investigators in the biomedical and behavioral sciences in the coming years?
3. What steps might be taken to improve the effectiveness of the NRSA program in recruiting women and minorities into scientific careers?
4. What features of the NRSA training grant might be strengthened to assure the maintenance of higher quality research training environments?

The Committee is also aware of significant changes that have come about in employment opportunities for bioscientists in industry and other types of nontraditional research settings. Relative to the research training areas of interest to you, we would also be interested in knowing whether you believe current employment opportunities have resulted in (or might be expected to result in) new research training strategies in the biosciences? What are the implications of those new strategies for the NRSA program?

We hope that you will take the opportunity to assist in our effort to gather the views of experts in the bioscience community by sending us a letter no later than March 29 to:

National Research Council

Office of Scientific and Engineering Personnel

Studies and Surveys Unit

2101 Constitution Avenue NW

Building 2133--202 (BBRP)

Washington, DC 20418

The Committee has designated an ad hoc panel to review the responses and to select the 35 individuals who will be invited to address the Committee at its May 3 hearing. We regret that we cannot accommodate more than 35 speakers plus commentary from the audience. However, be assured that all Committee members will receive for review the full set of materials generated by this letter of invitation when they are received.

If you have any further questions about the Public Hearing, please telephone Rob Murphy at 202/334-3982 for any further information about the meeting.

We know you share our concern that we provide a strong program of research training through the National Research Service Awards program and look forward to your suggestions for achieving that goal.

Sincerely,

Ira J. Hirsh
Co-Chair

John D. Stobo
Co-Chair

APPENDIX B

LIST OF RESPONDENTS

PUBLIC HEARING ON NATIONAL NEEDS FOR BIOMEDICAL AND BEHAVIORAL RESEARCH PERSONNEL NEEDS

May 3, 1993

Washington, D.C.

Graduate Deans

Catholic University of America
Mary Jean Flaherty
School of Nursing

Columbia University
Roger S. Bagnall
Graduate School of Arts and Sciences

Cornell University
College of Veterinary Medicine
Douglas D. McGregor
Research and Graduate Education

Harvard University
Christoph Wolff
The Graduate School of Arts and Sciences

The Mount Sinai Medical Center
Terry Ann Krulwich
Graduate School

Rockefeller University
Bruce S. McEwen
Graduate and Postgraduate Studies

Rutgers University-New Brunswick
Joseph A. Potenza
Graduate School

University of California-Los Angeles
Robin Fisher
Graduate Division

The University of Chicago
Jeffrey S. Slovak
Graduate School

University of Illinois at Urbana-Champaign
Chester S. Gardner
Graduate College

The University of Iowa
Leslie B. Sims
Graduate College

University of Missouri-Columbia
Judson D. Sheridan
Graduate School

University of Rochester Medical Center
George A. Kimmich
Graduate Studies

Grant Directors

Robert Ader
Center for Advanced Study in the Behavioral Sciences
Stanford, CA

Irwin M. Arias
Tufts University
Department of Physiology

Marilyn J. Aten
University of Rochester Medical Center
School of Nursing

David M. Austin
The University of Texas at Austin
School of Social Work

John L. Azevedo, Jr.
East Carolina University
School of Medicine
Department of Biochemistry

Donald Bartlett, Jr.
Dartmouth Medical School
Department of Physiology

Howard Baum
Massachusetts General Hospital
Neuroendocrine Clinical Center

Robert D. Blank
The Rockefeller University

Daniel F. Bogenhagen
State University of New York at Stony Brook
Department of Pharmacology

Selwyn A. Broitman
Boston University School of Medicine
Department of Microbiology

Nicholas Cohen
University of Rochester Medical Center
School of Medicine and Dentistry
Department of Microbiology and Immunology

Shelley A. Cole
Southwest Foundation for Biomedical Research
Department of Genetics

Robert E. Cone
The University of Connecticut Health Center
Department of Pathology

José R. Criado
The Scripps Research Institute
Department of Neuropharmacology

Bruce P. Dohrenwend
College of Physicians & Surgeons at Columbia University
Social Psychiatry Research Unit

Emanuel Donchin
University of Illinois at Urbana-Champaign
Department of Psychology

Brian R. Duling & Robert M. Berne
University of Virginia Health Sciences Center
Department of Physiology

Floyd Dunn
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Bioacoustics Research Laboratory

Lise S. Eliot
Baylor College of Medicine
Division of Neuroscience

Barbara L. Finlay
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Frances M. Finn
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Elizabeth A. Franz
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Robert N. Golden
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Lee Goldman
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Department of Medicine

Lowell A. Goldsmith
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Department of Dermatology

Richard J. Grand
Tufts University School of Medicine
Departments of Pediatrics

David Hamerman
Albert Einstein College of Medicine
Resnick Gerontology Center

Robert I. Handin
Harvard Medical School
Brigham and Women's Hospital
Hematology-Oncology Division

George A. Hedge
West Virginia University Health Sciences Center
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Research and Graduate Studies

Arthur Horwich
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William P. Jencks
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Department of Pathology

Walter Makous
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Center for Visual Science

Kenneth G. Mann
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Department of Biochemistry

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Richard H. Masland
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New York University Medical Center
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Neil Ruderman
Boston University Medical Center
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Marijane Russell
National Jewish Center for Immunology and Respiratory Medicine

Irwin Sandler
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Preventive Intervention Research Center

Peter R. Shank
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Herbert B. Silber
San Jose State University
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Robert Snyder
Rutgers University
Joint Graduate Program in Toxicology

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Georgetown University Medical Center
Department of Pharmacology

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Michael J. Zigmond
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Department of Behavioral Neuroscience

Professional Associations

American Academy of Nursing
Janet Heinrich

American Association for Dental Research
John J. Clarkson, Harold C. Slavkin

American Association of Colleges of Nursing
Geraldine Polly Bednash

American Association of Dental Schools
Preston A. Littleton, Jr.

American Chemical Society
Helen M. Free

American College of Dentists
Sherry Keramidas

American Dental Association
John S. Zapp

American Institute of Biological Sciences
Donald R. Beem

American Nurses Association
Barbara K. Redman, Ada K. Jacox

American Psychiatric Association
Harold Alan Pincus

American Psychological Association
Wayne J. Camara, James M. Jones

American Psychological Society
Alan G. Kraut

American Society for Biochemistry and
Molecular Biology
Charles C. Hancock, David Brautigan

American Society for Microbiology
Gail Cassell

American Speech-Language-Hearing Association
Frederick T. Spahr

Association for Health Services Research
John M. Eisenberg, Roger J. Bulger,
Alice S. Hersh

Association of American Medical Colleges
Robert G. Petersdorf, Thomas E. Malone

Association of American Universities
Cornelius J. Pings

Association of American Veterinary Medical Colleges
Ronald A. Wright

Consortium of Social Science Associations
Susan Persons

International Association for Dental Research,
Behavioral Sciences and Health Services Research Group
Jane A. Weintraub

Oncology Nursing Society
Mel Haberman

Society for Neuroscience
Dominick P. Purpura

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Marcia Sydney Zax

APPENDIX C

PUBLIC HEARING PROGRAM

PUBLIC HEARING ON NATIONAL NEEDS FOR BIOMEDICAL AND BEHAVIORAL RESEARCH PERSONNEL NEEDS

May 3, 1993

National Academy of Sciences Auditorium

AGENDA

8:00 a.m.	*Registration/Coffee*
8:45 a.m.	*Welcome and Introduction of Committee/Staff*
	• Ira Hirsh and John D. Stobo
9:00 a.m.	Susan Gerbi, Brown University
9:10 a.m.	David Brautigan, American Society for Biochemistry and Molecular Biology
9:20 a.m.	Terry Ann Krulwich, The Mount Sinai School of Medicine
9:30 a.m.	*Panel (Fellows/Trainees)*
	• Julia Fielding, Brigham and Women's Hospital
	• Vince LiCata, University of Minnesota
	• Ora Weisz, The Johns Hopkins University
10:00 a.m.	*General Discussion*
10:15 a.m.	BREAK
10:30 a.m.	Thomas Malone, American Association of Medical Colleges
10:40 a.m.	Bryan Marshall, University of Pennsylvania
10:50 a.m.	George Kimmich, University of Rochester
11:00 a.m.	*Panel (Fellows/Trainees)*
	• Miyuki Yamaguchi, Duke University
	• Joanne Pohl, The University of Michigan
11:30 a.m.	*General Discussion*
12 Noon	LUNCH
1:30 p.m.	Susan Persons, Consortium of Social Science Associations
1:40 p.m.	James Jones for Wayne Camara, American Psychological Association
1:50 p.m.	John McCormick speaking on behalf of Judson Sheridan, University of Missouri
2:00 p.m.	*Panel (Fellows/Trainees)*
	• Barton Giddings, Whitehead Institute for Biomedical Research
	• Phillip Cozzi, University of Chicago
	• Pat McCloskey, University of North Carolina at Chapel Hill
2:30 p. m.	*General Discussion*

2:45 p.m.	BREAK
3:00 p.m.	Gail Cassell, American Society for Microbiology
3:10 p.m.	Herbert B. Silber, San Jose State University
3:20 p.m.	Daniel Linzer, Northwestern University
3:30 p.m.	Ada K. Jacox, American Nurses Association
3:40 p.m.	*Panel (Fellows/Trainees)*
	• Thomas Meyer, Columbia University
	• Carey Nien-Kai Lumeng, University of Michigan
4:00 p.m.	*Panel (Training Grant Directors)*
	• Irwin Sandler, Arizona State University
	• Lee Goldman, Harvard University
	• Peter Shank, Brown University
	• Page Morahan, Medical College of Pennsylvania
4:40 p.m.	*Panel (Professional Society Representatives)*
	• Cornelius Pings, Association of American Universities
	• Alan Kraut, American Psychological Society
	• Harold Slavkin, American Association for Dental Research
	• Dominick Purpura, Society for Neuroscience
5:20 p.m.	Elizabeth Jones, Carnegie Mellon University
5:30 p.m.	J. Fredrick Dice speaking on behalf of Irwin Arias, Tufts University
5:40 p.m.	Homayoun Kazemi, Massachusetts General Hospital
5:50 p.m.	Richard Grand, Tufts University
6:00 p.m.	*General Discussion*
6:30 p.m.	ADJOURNMENT

APPENDIX D

TESTIMONY

STATEMENT BY IRWIN M. ARIAS, M.D.[1]

Based upon a unique and productive experience of the past seven years, I submit the following commentary in response to your inquiry of March 3rd.

Bridging the continuing rapid advances in basic biology with human disease is, in my view, the greatest challenge to biomedical research and offers the most promise in solving human disease.

The gap has become logarithmic and, like a huge suspension bridge, requires many types of wire, struts, and cable. Most efforts to train biomedical scientists are traditionally directed toward physicians and M.D./Ph.D. graduates. Ph.D. graduates are not trained to appreciate pathobiology and, in most medical centers, it is difficult to recruit outstanding basic scientists into clinical departments primarily because, as one of my students succinctly stated, “You work for physicians and not with them.”

Students graduating from basic science departments in medical schools should be important components of the bridge; however, this is infrequent. These students enter programs in medical schools because they wish to work on problems related to human disease. Invariably their academic program, research, and career choice are no different from what would have taken place had they been 100 miles away from a medical center. Approximately six years is spent in the shadow of a great medical center, but the student rarely knows what goes on there. More importantly, brilliant students know little about inflammation, fibrosis, necrosis, and other disease mechanisms. The students reflect the orientation of their mentors and, upon graduation, infrequently seek careers which primarily influence human health.

As the number of physician-scientists declines, basic scientists who are sufficiently trained to demystify human pathobiology find exciting and productive careers in clinical departments. These departments have adjusted to changing times by solving academic problems which restrict basic scientists in such departments.

In the past seven years, we have trained 63 predoctoral students, 22 postdoctoral fellows, and 6 Ph.D. faculty in the hands-on pathobiology of 20 major human diseases. Our students see patients, handle pathology, and are exposed to every major diagnostic and therapeutic facility in a modern hospital. The program is detailed in a New England Journal of Medicine article (for which we have received over 1200 reprint requests) (Arias, 1989). The Macey, Rockefeller, and Markey Foundations support this program which has graduated 22 students, 16 of whom work in biomedical science research.

Our experience prompts the following suggestions:

1. Training appropriations, plans, and programs should include demystifying disease for basic science students and fellows.
2. Institutional solutions to time-honored problems of the Ph.D. in a clinical department should also be encouraged and supported.

Summary

Bridging basic science with medicine requires many components. The academic physician scientist is a critical player; however, Ph.D. students who demystify disease are major but neglected components. Programs which train basic scientists who can work

[1] Testimony presented by J. Frederick Dice, Department of Physiology, Tufts University School of Medicine.

"with" rather than "for" physician scientists should be encouraged.

At a time when basic science offers unparalleled opportunities to understand disease, it is remarkable that the goals of most graduate students are unfulfilled, and their talents are not directed to biomedical science.

REFERENCES

Arias, Irwin M. 1989 Training basic scientists to bridge the gap between basic science and its application to human disease . *New England Journal of Medicine 321 : 972-974* .

STATEMENT BY DAVID L. BRAUTIGAN

Good morning. Ladies and gentlemen, I am here representing the American Society for Biochemistry and Molecular Biology (ASBMB), a non-profit, scientific, and educational organization with over 9,000 members. Currently I serve as the Chairman of the Human Resources Committee, the largest committee for ASBMB, which deals with education issues in general as well as particular problems faced by women and under-represented minorities. We are organized into three subcommittees focused on each of these areas.

A majority of our members teach and conduct research at colleges and universities. Sustaining the quality of biomedical and behavioral research is a critical issue of great concern to us. I was a recipient of both predoctoral training grant support at Northwestern University and a post-doctoral NRSA award with Edmond Fischer, the 1992 Nobel Laureate, at the University of Washington, Seattle. I believe these mechanisms of support for those in training goes hand-in-hand with the government's role in financing fundamental research in the life sciences. This combination of research and training support has considerable and continuing benefits to the health and welfare of the citizens of our country.

Now I will respond, in turn, to the four questions posed by the committee.

First, *what is the most significant challenge we face today?* It is the lack of funding available to support the scientists currently in the field who are capable of excellent research. A telling statistic is the declining success rate for research applications submitted to the National Institutes of Health. In 1991, the average NIH success rate was 29.3 percent. It is likely that less than 1 in five applicants for an NIH research grant will actually be funded this year.

The impact on NRSA programs is obvious. The best and the brightest students see little incentive for them to take up life sciences research as a career. They suspect that after years of rigorous training, funding for research may be as scarce as it is today. Sadly, this decision is often made even before they gain enough exposure to research to become committed to it, as happened to most of us here today. Rather, many opt to enter some other career, such as the practice of medicine, where the likelihood of reward and recognition is greater. The number of quality students interested in research is small; we have to encourage them and provide them with opportunities.

We need to sustain our training programs. As the large cadre of older life scientists in universities retire and life sciences-based industries continue to expand, the current surplus pool of life science researchers will evaporate. We have to remain aware that quality training programs take years to assemble and mature. These programs do not need to continue to grow in size, but they cannot survive if their support goes up-and-down in cycles.

That brings me to question 2, about *improvements in the National Research Service Awards program.* Let me make 4 recommendations:

First, do not expand, but do maintain most programs at their present levels. The Federation of American Societies for Experimental Biology (FASEB) has conducted a consensus conference on biomedical research funding, and recommends that the NRSA program support 14,020 training positions. As Professor Gerbi has pointed out, this number of students actually is a small fraction of total Ph.D. production, but represents our best programs, chosen by merit.

Second, support measured and prudent growth in the Medical Scientist Training Program (MSTP) which awards both M.D. and Ph.D. degrees after a rigorous course of study. This is recognized as the most successful NIH training program. The MSTP should be provided with funds to add 250 trainees over the next six years to bring the total number to 1,000 trainees.

Third, increase stipends for all pre- and postdoctoral trainees. Current stipends are inadequate; awardees are supported below the poverty line and

require some supplementation to stipends to meet basic needs.

Fourth. FASEB supports the creation of a predoctoral fellowship program, for individual predoctoral students, to eventually support about 1,000 fellows per year after five years. Such a program will allow the best students to train with the faculty of their choice, whether or not there is an institutional training grant.

Question 3. *What steps might be taken to improve the effectiveness of the NRSA program in recruiting women and minorities into scientific careers?*

Women. The number of women in the life sciences has increased dramatically in the last 20 years, from a few percent to more than a quarter of all life scientists. However, women in life sciences are faced with problems associated with career advancement such as the so called "glass ceiling. " One suggestion for the NRSA would be to specifically encourage applications from women who have taken time off in early or mid-career to raise children. When women return to the laboratory after an absence for child-rearing (which can amount to years) they need some time to come "back to speed" on a research project of their own. Individual fellowship support for these women would be especially effective in providing them with opportunities.

Underrepresented Minorities.

African-Americans, Hispanics, and Native Americans account for no more than a couple of percent of all Ph.D.s in the life sciences. These numbers have been constant for two decades, and show few signs of improving.

Most under-represented minorities with a desire to work in life sciences are not entering Ph.D. programs, but instead are going to medical school. The Association of American Medical Colleges (AAMC) has reported that in 1991, 918 black Americans, 46 Native Americans, and 362 Hispanic Americans graduated from medical school (total 1326).

By comparison only 6 black Americans received Ph.D.s in biochemistry in 1991, according to the National Science Foundation, and only 44 Ph.D.s were awarded to black Americans in all the biological sciences combined. Likewise, 10 Native Americans and 78 Hispanic Americans received a Ph.D. in the life sciences (total 132). So there were 10 M.D.s for every Ph.D. earned by members of these groups.

My suggestion is to promote aggressively the Medical Scientist Training Program, especially to minority students in premedical programs. Many observers are concerned over the decline in the number of M.D./Ph.D. researchers, and FASEB has recommended that this program be expanded. Promoting the MSTP program to minority undergraduates would be a way to solve two problems at one time. Minority students could attain their medical degrees, but would also be trained to do research. One could also promote the MSTP to minority students after they have entered medical school, and this is an especially promising way to capture them for careers in research.

Lastly, Question 4. *What features of the NRSA training grant might be strengthened?*

I believe that concentration of NRSA recipients, especially postdoctorals, in a few laboratories is a problem. The selection process picks the best students from an elite group of programs and puts them in a few laboratories of the most readily recognized sponsors. These groups swell in size because salaries are provided. With this system postdoctoral trainees become concentrated in laboratories with many other postdocs, and they do not receive much attention and have limited interaction with faculty. There are, in fact, many top caliber laboratories that would be excellent training environments. I might go so far as to "cap" the number of postdoctorals awarded to any individual sponsor.

You also asked whether "significant changes that have come about in employment opportunities for bioscientists in industry and other types of non-traditional research settings" have affected, or will affect, how students in the biosciences are trained. It is the view of ASBMB that the best training students can receive is broad-based. Students are attracted to interdisciplinary training programs in the life sciences, and I think we should encourage this. The ASBMB Educational Affairs Subcommittee conducted a national survey of both graduate schools and industry for information on what course work they like prospective students or employees to have taken at the undergraduate level. A solid background in general biochemistry and molecular biology is very much desired. Focused programs such as biotechnology can be obsolete before the degree is awarded and these are not considered the best investment.

Overall, the research community supports the efforts of this Committee and we depend on you being effective as our representatives.

STATEMENT BY GAIL CASSELL, Ph.D.[2]

We appreciate the opportunity for the American Society for Microbiology (ASM) to respond with some preliminary comments to the four questions, which you posed in your letter of March 2, concerning the future direction of the National Research Service Awards (NRSA) program. The ASM is the largest single life science society in the world with over 39,000 members. Many ASM members are investigators or trainees in the biomedical sciences. The ASM shares the goal of the NRSA program to help ensure that highly trained scientists are available in adequate numbers and in the appropriate research areas and fields to carry out the nation's biomedical research agenda. In the short time available, we have consulted with members of ASM's Public and Scientific Affairs Board (PSAB) and its Committees on Manpower Planning, Status of Minority Microbiologists, and Status of Women in Microbiology in an attempt to provide the following preliminary views on research training issues for your consideration. The ASM has testified previously before the NRC Committee on National Needs for Biomedical and Behavioral Research Personnel, and we very much appreciate the opportunity to address the Committee at its May 3 hearing.

1. *What is the most significant challenge we face today in the United States for maintaining an adequate supply of qualified scientists to sustain and advance health research?*

Increased attention to research training is required for the existing and emerging needs in health as well as in environmental and agricultural research, and to continue the preeminence of the U.S. academic/ industrial research enterprise as the foundation for national economic competitiveness. With a decade-long pipeline (from college student to beginning scientists), it is crucial that anticipated areas of future shortages be addressed now to ensure an adequate supply of American scientists to conduct scientific research in the next century.

Our most significant challenge is to reliably predict training needs in specific areas of the biomedical sciences. To do this we must accurately determine the current number of trainees in different disciplines, as well as the number choosing different career paths, i.e. industry, academics, or health related professions. This information is not presently available. The ASM believes there should be an ongoing evaluation of areas in which training should be intensified and of approaches for NIH and other government funded research training programs to respond to evolving needs. The ASM is currently planning to conduct a survey to assess the needs and current status of training of personnel in the microbiological sciences, with particular emphasis on the needs of industry, academe, and clinical, including hospital, sources for trained microbiologists. We would like to determine where needs exist and whether current training programs are meeting these needs. We believe it is very important to collect data and conduct analyses of the needs of employers to ensure that NIH training programs are matched with existing needs of users, both in academe and industry. We believe that assessment of training needs must take into account opportunities in new and emerging research areas, actual job opportunities, and the effect of funding issues on young investigators and those interested in biomedical research careers. We are also interested in how the NRC studies will be linked to the NIH Strategic Plan.

Recruitment of highly talented individuals to fill training needs in biomedical research will continue to be a major challenge. This will depend on competitive stipend levels for trainees as well as assurance of career opportunities. The ASM is very concerned about biomedical research funding issues and the impact of a steady state research training budget on the development of new investigators, particularly in areas where new research personnel needs are emerging, e.g. molecular biology and biotechnology. We are concerned about the negative effect of the current funding climate for biomedical research in the U.S. and the reduced funding rate as well as the number of RO1 grants as a signal of lack of career opportunities for young investigators and for students considering a career in the biomedical sciences.

Relative to the research training areas of interest to you, we would also be interested in knowing whether you believe current employment opportunities have resulted in (or might be expected to result in) new research training strategies in the biosciences. What are

[2] Co-authored with Kenneth Berns, M.D., Ph.D., John Ingraham, Ph.D., Ron Luftig, Ph.D., and Janet Shoemaker, American Society for Microbiology, and prepared at the request of John Ingraham, American Society for Microbiology.

the implications of those new strategies for the NRSA program?

The microbiological sciences, which provide needed manpower for the biotechnology as well as pharmaceutical industries, are experiencing a need for well trained, highly qualified scientific personnel. For example, over the past several years there has been a decline of graduates with high quality training in microbial physiology. Training of microbial physiologists has been neglected by academic departments and, in some centers, has been almost entirely supplanted by molecular biology and genetics (R. Hinman, ASM News 5 8:62-63, 1992). This has resulted in a serious shortage of both Ph.D.s and postdoctoral trained to address physiological problems of the type essential to the successful development of fermentation processes. This shortage is felt especially acutely in the U.S. pharmaceutical industry, but it is also critical to industries seeking to utilize biotechnology for improving animal health care, agriculture, and environmental remediation. We have made great strides in mastering the use of recombinant DNA and other techniques for genetic manipulation to construct novel organisms, but the full potential for expression by these organisms can be realized only through optimization of physiological conditions. Molecular genetics is the beginning of the industrial process. A microbiologist now working in industry should have broad training that gives a thorough understanding of the microorganisms and their environment.

Well-trained microbial physiologists have the tools to advance biotechnology. We place special emphasis on microbial physiology because it is critical to continued progress in the applications of biotechnology in medicine, the environment, and agriculture. Although we agree that there is need for biotechnology to make greater use of new and nontraditional organisms, the full potential of familiar microorganisms of proven value in biotechnology will not be realized until more is known of their physiology. Funding for research training in microbial physiology must be increased to strengthen the foundation on which future advances in biotechnology can be constructed.

The ASM wholeheartedly concurs with the February 1992 FCCSET Committee report that training is critically needed in general microbiology and “that the disappearance of general microbiology departments from many American universities has not been compensated by the development of a modern equivalent. As a result, the study of diverse bacterial and other microbial populations is being hampered by a lack of adequately trained researchers.”

There also has developed a need for individuals trained in environmental biotechnology. It is important to recognize that need exists for increased attention and support for training at the graduate and postgraduate levels in environmental microbiology and biotechnology. These areas combine traditional learning with recent developments in molecular biology and genetics. Based on data from the ASM Placement Activities report for 1991, there is an increasing need for employees trained in the environmental area, although the totals are not yet large. A few years ago there was no call for individuals trained in this area.

Critical manpower needs in specific areas of microbiology that mainly impact biotechnology industries suggest to the ASM that more emphasis should be placed on establishment of training programs which would be jointly sponsored by academic institutions and industry. Such training programs could be directly industry related.

2. *What improvements might be made in the National Research Service Awards program to assure a continuing supply of skilled investigators in the biomedical and behavioral sciences in the coming years?*

Addressing stipend inequities should be a high priority for the NRSA research training program provided the total number of trainees is maintained at or near the target recommended by the NAS. In the absence of adequate stipends, we will not be able to recruit the best young scientists into the biomedical laboratories of the future. At the current time, NIH predoctoral stipends are at $8,800, which is considerably below the current cost of living. Furthermore, it is below the poverty level for an income of two which is presently $9,190. Predoctoral stipends should be increased into a range that is competitive with stipends paid by other federal agencies, e.g., most state university stipends start at $11,000 and NSF currently pays $14,000. Additionally, the NIH conducted a review of its biomedical research training programs in 1989 and concluded that major increases in postdoctoral stipends are warranted. This is particularly true for the first two postdoctoral years for physician trainees when NRSA stipends are considerably below housestaff salaries. It

becomes very difficult at this important period of training to entice a clinician into a research career when he or she would have to face a considerable reduction in compensation.

To assure a continuing supply of skilled investigators in the coming years, more attention should be given to developing better approaches to identifying individuals with the best potential to become successful research scientists. In comparison to other professions (medicine, dentistry, law, etc.), few studies have been bundertaken to determine the best predictors for successful researchers so that this information can be incorporated into admission criteria to graduate school. Likewise, little hard data are available as to what constitutes the best methods of training successful investigators.

3. *What steps might be taken to improve the effectiveness of the NRSA program in recruiting women and minorities into scientific careers?*

The ASM's Public and Scientific Affairs Board Committee on Manpower Planning conducted a survey during the 1987-88 academic year to document the demographics of microbiology students and faculty in the U.S. The survey addressed age, gender, race and ethnicity of microbiology trainees and faculties at all levels. It was sent to departments in institutions that offer degrees in microbiology. Of the 363 departments contacted, 125 (34% of the total) responded. However, these 125 institutions account for 72 percent of Ph.D.s in microbiology awarded in 1987. An article published in ASM-News in January 1990, based on the survey, points out that shortages can be anticipated in the future in the microbiological sciences and that minority representation in microbiology departments is very poor. Female representation among microbiology faculties was also shown to be poor, although female representation appears to be better at the lower professional and trainee levels.

In answer to this question, we agree with and include the following specific comments from the response to this question developed by the ASM's Committee on the Status of Minority Microbiologists, chaired by Dr. Gerald Stokes of George Washington University: The structural organization of the NRSA-sponsored minority predoctoral awards is overly restricted, underfunded, and fails to recognize the diversity of highly qualified minority applicants. The NRC should develop a coordinated effort to assist the funding of a greater number of qualified minority applicants than is currently being done. This load could be shared with other federal funding agencies or federally funded university training programs for award considerations. Students should be able to apply for NRSA support, with awards contingent upon being admitted to graduate school. The NRSA award criteria is heavily weighted towards student performance on standardized examinations. Some consideration should be given to the fact that minority student performance is consistently below national averages on such tests. The current process neglects to realize the diversity of personality traits which may factor into the production of a well-rounded academician or scientist.

Competitive renewals for 732 NRSAs now must include detailed summaries of minority recruitment, not only at the level of the institution as a whole, but also at the departmental and individual mentor level. All the NIH institutes should rigorously review this information and enforce this requirement which should result in increased recruiting activities and, consequently, in increased numbers of minority trainees. Review criteria should also include efforts to increase retention of minority students. Special support services are needed to retain even the best minority students.

The NIH Office of Research on Women's Health has established a program to encourage women to return to science careers. The ASM's Committee on the Status of Women in Microbiology, chaired by Dr. Anne Morris-Hooke, notes that although many women are entering the profession of microbiology, a number leave at the doctoral and postdoctoral levels. They suggest one approach to recruiting those who have left research careers for family or other reasons, is to target some NRSA funding directly to women who are trying to reenter science at the graduate level. Also the Committee on Women in Science and Engineering of the Office of Scientific and Engineering Personnel of the National Research Council recently published a report entitled "Women in Science and Engineering: Increasing Their Numbers in the 1990s," in which the following recommendation was made: "Government subsidies or grants from private foundations for child care to undergraduate and graduate students and postdocs might also serve to recruit more women into scientific and engineering careers." Consideration should be given to increasing the length of time allowable for support of females on NRSA awards when adequate time for maternity leave and the ability to receive training at a slower pace during the early phases

of child development are needed. A number of medical schools have increased the time from 4 to 6 years allowable for completion of undergraduate medical education.

4. *What features of the NRSA training grant might be strengthened to assure the maintenance of higher quality research training environments?*

The biggest problem with the research training environment today is related to underfunding of research and the fierce competition for scarce resources. Because the laboratory work of trainees is directly linked to external funding sources, there is more pressure for trainees to produce results at a faster rate and, in many cases, to publish prematurely. Mentors must spend less time in the laboratory directly supervising trainees and more of their time writing grant applications. This also results in less time spent on lecture preparation and fewer numbers of seminar and advanced courses being offered at most institutions. Additional funding is required not only for NRSA training awards but also for research project grants in order to attract and retain the best students and to ensure an excellent training environment. Stipend levels should be increased, and money should be added for laboratory training related expenses such as research supplies and equipment. This would protect trainees from interrupted funding of the mentor's research program.

NRSA training program environments could be improved if all components of training were more rigorously reviewed. In addition to numbers of students and trainee publications, criteria should be developed measuring the effectiveness of mentors. Not enough attention is being given to coursework or actual teaching of research skills. Minimal criteria should be established for NRSA training programs. Every trainee (pre- and postdoctoral) should be required to complete a course in experimental design and statistical analysis, grant writing, oral scientific communications, and public science policy. To give students a well-rounded education, they should also be exposed to grant accounting and management and a minimal amount of teaching experience.

The ASM supports the NRSA requirement for training in the responsible conduct of research. We would like to point out that the ASM's Academy of Microbiology is planning a series of colloquia to assist faculty in the development of specific curriculum content for teaching scientific integrity to students, with specific reference to developing information on two of the most challenging issues, conflict of interest and collaborative research.

STATEMENT BY PHILLIP J. COZZI, M.D.

Thank you for your interest in my opinions on health research. My salary is supported by an individual NRSA. In response to your specific questions:

1. *The most significant challenge in maintaining an adequate supply of qualified health researchers is enlisting top students and physicians in the face of financial disincentive and insecurity.* I attended the University of Chicago Medical School, performed both internal medicine residency and chief medical residency at Northwestern University, and now I am a fellow in Pulmonary and Critical Care Medicine at the University of Chicago. I have enjoyed and participated in medical research at every stage of my education from college to the present. All of a sudden, however, life as a medical researcher is less attractive to me. This change is temporally and causally related to the birth of my second child. We have no savings, large debt and, as my family grows, ever-increasing financial responsibility. My wife is a stay-at-home mom; my monthly paycheck, six years after getting an M.D. degree, is $1843 and is entirely consumed each month.

We live in a small apartment with no backyard in an industrial park in the western suburbs of Chicago. Although my wife and I were perfectly happy to live on a very tight budget, we want more for our kids. We hope to buy a house so that the kids can have a backyard and simply a place to be. With sheer optimism, maybe we can afford a house in 4 to 5 years. I love research but this ongoing financial deprivation may drive me out of academics.

Aside from my concerns about the present, I am just as worried about the future. To keep an academic position at good universities today, independent funding is usually needed. If one loses their grant, they usually lose their position as well. I am reluctant to place my family's financial security at risk.

2. *Ideas for improving the NRSA program: a). pay better (vide supra); b). eliminate the payback period.* This is simply a disincentive to applying; we want our options open. Also, it is unreasonable to expect us to commit our futures to medical research when funding for the vast majority of grant proposals is denied.
3. *To stay at the cutting edge of science, the United States needs the creativity of all of its citizens regardless of sex or race.* Other than by making changes in society's views on science and expanding educational opportunities early in training, minorities and women will have chosen other careers long prior to the point at which one applies for a NRSA.
4. *To assure maintenance of high quality research training environments, you might consider site checks and personal interviews with recipients.*
5. *Opportunities exist in the private sector.* Young investigators can get funding from pharmaceutical houses to continue work at universities, or they can become employees of pharmaceutical houses. The latter option is satisfactory from the financial perspective, but is unsatisfactory for several reasons. Firstly, investigators must follow an agenda designed to make marketable products. The profits from basic science are distant; industry is short-term profit oriented. Consequently, basic investigations may be ignored and investigator autonomy lost. Secondly, the option to practice clinical medicine may be limited to participation in drug trials.

The relationship between pharmaceutical houses and universities is complex. We need each other. The pharmaceutical houses need the universities to provide basic science on which industry can capitalize. Academia needs industry for financial support. The opportunities for collaboration are boundless, yet unrealized. In identifying why academia and industry have collaborated poorly, changes may be made to improve the relationship and promote better health research. Possible explanations: 1) greed - each wants all the profit and recognition. 2) survival - different laboratories pursue parallel lines of research; one lab may be "scooped" by another and, therefore, be reluctant to share technologies and talent. What can be done? Talent, technology, and money can be shared with explicit agreements that resultant profits (long- or short-term) and recognition will be shared likewise.

What are the implications of collaboration between industry and academics for the NRSA program? Pharmaceutical houses should consider providing similar awards with the proviso that profits from discovery will be shared. I do not favor the approach of funding research with charitable donations from industry because I doubt this will result in significant increases in cash-flow into academics beyond the present level.

STATEMENT BY JULIA R. FIELDING, M.D.

Although the economic and political climate remains chilly for researchers and scientists, it is vital that we increase the number of competent thinkers in preparation for the twenty-first century. I believe that early encouragement of capable students in combination with sound teaching and support from programs such as the National Research Service Awards Act is the route to success.

In order to produce competent thinkers by age 18 we need to teach science and mathematics effectively beginning at age 6. Many of us were first encouraged to think independently by an elementary school teacher. It seems that during the next four years there will be more emphasis placed on primary education in the public schools. Hopefully this will translate into more money for books, equipment, and high quality teachers. There is, of course, still no substitute for hard work in mastering basic critical thinking skills, and parents and teachers need to drive that message home. Science should, however, be made attractive by including experimentation, discussion and competition. Many scientific concepts are of real interest to children today including the meteor theory of dinosaur extinction, the building of the space station, and computer generated animation. People who work in scientific fields should be brought to schools to put a human face to less exciting concepts. Team discovery projects, science fairs, and science camps are fun ways to teach scientific methods. Finally, parents and educators must convey to children the joy that comes from mastering difficult tasks. The usefulness of long term goals and community service must be stressed to combat the instant gratification provided by television and other distractions.

High school and college are the times when mentoring can be very effective. In my case, the best

mentors were often the best teachers because of the obvious joy they took in their subjects. It is particularly important to encourage women and minority students to continue with math and science courses. Social gatherings and clubs are useful in disseminating the idea that a career in science is possible for anyone. A directory of available science and math scholarships would be very useful, if such a thing does not already exist.

Once committed to a scientific career, trainees are very dependent upon senior staff mentors. A good mentor will critique work, teach new techniques, maintain high ethical standards and encourage a young career. Unfortunately, not all laboratory managers or department heads are perfect, and problems do occur. The National Research Council might consider requiring yearly plans for the training of young scientists to ensure money is being appropriately spent and that educational plans are sound. Another option would be to hold yearly conferences at which trainees would present their work. In this way, young investigators would gain experience in presentation, be critiqued by their peers, make personal connections in the science fields, and gain some prestige at their home universities. At the same time, NRC representatives could assess the quality of work presented and identify problem institutions or individuals.

During the past few years, it has become difficult to decipher scientific literature. Everyone seems to be using a different type of statistics and jargon. In the cost and result conscious environment of the next century, this will not be tolerated. Writing and communication skills must be taught so that trainees will be effective in competing for grant money and in getting their work published and understood. This could be accomplished by required courses in college or graduate school and also be included in a national workshop format.

With the coming reforms in health care and the planned reductions in funding of basic science research, we must ensure that women professionals are not economic casualties. In my department we have one extra physician than strictly needed to cover for maternity and paternity leaves in addition to scientific meetings and vacations. It is our view that raising children is desirable as well as necessary, and we plan accordingly. It would be terrible to see promising careers derailed because of conflicts between the ever increasing pressure to publish and produce and family needs. Department heads need to be aware of the value of their female colleagues and do their best to support their careers.

STATEMENT BY SUSAN A. GERBI, Ph.D.

Thank you for the opportunity to comment on the impact of National Research Service Awards (NRSA) on the training needs of our country. This is an area of interest to me, having served on the NIH study section for training grants in Genetics a dozen years ago, and I have been serving as the Program Director of the NIH training grant in Molecular and Cell Biology at Brown University for the past decade. Also, as President of the American Society for Cell Biology, I have an interest in the issue of research and training. It is now many years since I served as a member of your Committee, and I note that the basic questions being addressed never change, and the answers are still somewhat elusive! In the current climate of trimming budgets to reduce the federal deficit, Congress is sure to view the NRSA program in a critical fashion, and the report of your Committee is extremely important for continuation of the NRSA program at current levels. I will confine my remarks to the biological sciences, with emphasis on the subfields of cell and molecular biology with which I am most familiar.

Why should the biological sciences be singled out for special federal support of research training, unlike many other disciplines?

It is important to attract students into careers in biomedical research as the future manpower for our nation to insure that research advances continue to be made to reduce human disease and reduce the cost of health care. Therefore, this training area is one of national need that deserves special funding, thus setting it apart from other disciplines.

Students attracted to this area have the career options of obtaining a Ph.D. and doing research, or obtaining an M.D. for clinical practice. Salaries for medical doctors are much higher than for Ph.D. researchers. Also, there is much greater job security for medical doctors. Given these facts, one would expect the brightest students to go to medical school rather than graduate school, and indeed this is often the

case. Predoctoral fellowships are bait to try to lure gifted students into a research career.

What are the future manpower needs of our country in the biological sciences?

For the past few years it has been claimed that there is about a 1:1 correspondence of Ph.D. production and job opportunities. It was anticipated that a wave of retirements of faculty in academia would begin in the 1990s, creating a need for their replacement. With a change in retirement policies on the age for retirement, this wave may begin somewhat later in this decade than projected but I do not think the initial projection will be far off (most faculty whom I know are still choosing to retire at age 65). However, the end of the baby boom reaching college age means that there are fewer applicants. This coupled with the tight economy and reducing federal support for educational institutions (e.g., decreased indirect cost recovery) means that many colleges and universities are reducing the number of faculty slots to be filled. Another career opportunity that has increased dramatically in the past decade is in the biotechnology industry. However, most of these companies are still in the R&D mode, with few products yet marketable. In our lean economy, most of these companies are suffering, as can be seen by their stock values which have plummeted. Thus, the picture is not one of major growth of job opportunities in this area either. Your Committee should acquire statistics to see if my impression of decreased job growth in academia and industry is real. Also you will need to wrestle with the unknown outcome of how this may change if the economy rebounds.

The scenario I have painted suggests there is a current Ph.D. overproduction. Indeed, talented postdoctorals at some of our top schools are lined up in a holding pattern, waiting for a good job amid fierce competition. On the other hand, there is enormous promise of exciting applications of biological research in medicine, agriculture, and other areas of our society, and one could argue that the field is ripe for further expansion with unprecedented payoffs for the lives of our citizens. So, we have the dilemma: should we cut back on Ph.D. training, maintain it at current levels, or allow it to grow?

Except in industry, research grants are vital to carry out the research for which Ph.D.s have been trained. As you know, it is increasingly difficult to acquire federal funding for research. Where once one out of three individual investigator initiated research grants were funded at NIH, this success rate is now usually below one in five. The situation is even worse at NSF. Congress has been generous in the past in increasing the NIH budget, but inflation, other mechanisms and programs for funding in the portfolio, and increased bureaucracy have reduced the number of new grants being awarded. As we continue to churn out Ph.D.s, the competition for limited grant resources can only become worse. To correct this situation we have argued that the NSF budget should be doubled in the next five years, and there should be a 13% increase in the NIH budget next year (FASEB Consensus Conference on FY 1994 Federal Biomedical Research Funding). With the tight economy of our nation, this is very unlikely to occur. The other route to correct the success rate is to reduce Ph.D. production. However, any suggestion to reduce Ph.D. production should be counterbalanced by the realization that those choosing jobs in industry (biotechnology, pharmaceuticals, etc) do not need to write grants, so will not be competing in the grant pool.

Can predoctoral training grants influence the number of Ph.D.s being produced in the biological sciences?

After your Committee has debated what the optimal number of Ph.D.s being produced should be, the next question is how to regulate this number. For Ph.D. graduates in biomedical sciences, 15 percent of male and 20 percent of female graduates were at some point supported as predoctoral trainees. This percentage is higher than I would have guessed, but still sufficiently low that it does not significantly alter Ph.D. production. Most students are supported as teaching assistants or research assistants.

Universities are under the gun with reductions in indirect cost recovery, and research grants are harder to get and are cut in amount, so there are few alternative sources of funding to pick up the slack if a training grant is lost. If anything, the site of training might shift from the top schools which currently hold training grants to lesser schools, where students are not supported on training grants, thereby compromising the quality of predoctoral training. In the early 1970s, when several schools lost their training grants, there was no marked change in national Ph.D. production, though I suspect that the site of training changed. Indeed, this was true for Brown University where the number of predoctorals entering into our Ph.D.

program in Molecular and Cell Biology was drastically cut when we lost NIH training support.

The optimal number of predoctoral trainees must be determined by arguments other than numbers of Ph.D.s. we need to produce. The argument becomes one of quality rather than quantity (see below). I believe that the current number of 14,020 predoctoral traineeships is about right, since the study section is able to fund most of the deserving applications for institutional training grants. Due to the budget crunch, it could be argued that tuition charged to training grants should be capped in order to maintain the current number of slots, and your Committee may want to debate the pros and cons of this.

This situation is to be contrasted to MSTP grants, where several quality programs go unfunded. The pool for M.D./Ph.D. training is sufficient to request a modest increase (e.g., add 250 positions over the next six years to reach a total of 1,000 MSTP trainees; see FASEB Consensus Conference on FY 1994 Funding). However, this program is much more expensive than Ph.D. predoctoral training, and you must examine its cost effectiveness. A less costly route to train M.D.s in research is by individual postdoctoral fellowships, but the debt to be paid off from medical school makes this less attractive.

Nonetheless, surprisingly, about half the 5700 individual NRSA postdoctorals are held by M.D.s as compared to Ph.D.s.

Your Committee should examine whether the number of individual NRSA postdoctorals is appropriate. As jobs get scarcer, this is an important holding pool for trained manpower to fill future needs. If there are about 2,000 new NRSA postdoctoral fellowships per year, and half or 1,000 go to Ph.D.s, this means that one third of the 3,000 Ph.D.s produced each year succeed in getting an individual NRSA fellowship. You should confirm if this extrapolation is correct. You might examine the thorny issue of whether a cap should be placed on the number of individual NRSA fellows per lab, as it seems like the rich get richer and the poor get poorer. Most NRSA fellows are based at only a handful of academic institutions, though one could argue that these prestigious schools have the top quality labs. It would be interesting to compare the institutional distribution of (a) R01 research grants and (b) NRSA individual postdoctoral fellowships to see if they are coincident or not.

What is the justification for NRSA predoctoral training grants?

Since graduate students are also supported from research grants, why not use this mechanism rather than training grants? What is the advantage of institutional grants over individual fellowships? Usually students are trainees in their first two years of graduate school, when taking courses and research rotations. Training grants afford a flexibility in choice of mentor that would be impossible if students were locked into a particular lab's research grant in their first year. It is inappropriate to have students take courses when they should be spending their full effort on research for the research grant which supports them, so research grant support is best justified for more advanced graduate students.

Institutional training grants are a good example of the sum being greater than the parts:

(A) The QUALITY of the entire predoctoral program is improved and nontrainees in that program benefit as well as trainees. In the mid-1980s, Porter Coggeshall of the NAS staff did a study on career outcomes. Trainees did better than nontrainees. Your Committee may want to update this study.

(B) Training grants induce an interdisciplinary focus. It is difficult to predict emerging fields, so predoctorals with broad training are best qualified to meet the changing manpower needs of the future. In a few cases, where emerging fields with manpower needs can be identified, it is appropriate to have small programs of more specialized training grants (e.g., biotechnology; structural biology; the interface of chemistry and biology).

(C) Training grants provide the leverage that would be impossible on individual research grants to influence programmatic aspects. For example, schools with training grants must provide training on ethical issues. Also, they must be proactive in minority recruitment.

Finally, with regard to the specific questions of your March 3rd letter,

(1) Challenges we face: Your Committee should verify that the number of U.S. citizens applying to Ph.D. programs in the biological sciences is decreasing. The slack in U.S. applicants has been taken up by foreign applicants of high quality, especially from Korea, China, and most recently from Russia. At

Brown University, although the total number of U.S. applicants to all Biomedical Ph.D. programs has remained constant, they have dropped from 68% to 36% of the pool which has increased due to foreign applicants (Table I). In 1990, 30 percent of the Ph.D. recipients in the United States in science and engineering were foreigners. Many of these foreigners wish to remain permanently in the United States, but it is too soon to tell how many will return to their home countries. Are we training our economic competitors of the future? Unfortunately, NRSA awards are not the engine that drive this train, and can only modestly help to lure U.S. students into Ph.D. programs in the biological sciences. The major concern students have is whether there is a rosy career likely in their future. Fierce competition for jobs is not attractive. When they see their own college faculty rewriting research grant applications multiple times, only to be demoralized at not being funded when the reviews are excellent, students shy away from following this career path. Better job and grant opportunities are needed to attract our best U.S. students into careers of biological research.

(2) Improvements needed: The stipends for predoctoral trainees and postdoctoral fellows are too low. Most schools have to bend over backwards to find a way to supplement predoctoral stipends to raise them to about $14,000 because supplementation from other federal sources (e.g., research grants) is not allowed. The current stipend is below the poverty line! The stipends for postdoctoral fellows, especially in their first two years, is also too low when compared to salaries for other jobs even without such advanced training. Most predoctorals and postdoctoral work far in excess of a 40 hour week, so the hourly wages could even fall below minimum wages! In both cases, there should be a yearly increase of stipend levels to adjust for inflation rather than waiting about half a dozen years. Adjustment of stipend levels must be built into the NIH budget as an increase; it cannot come out of other sources and should not be counterbalanced by a decreased number of NRSA trainees/fellows (as happened at the time of the last stipend increase).

It was helpful when payback for the first year of NRSA support was waived. It would be useful to investigate the number of predoctoral trainees that drop out. If more than 95% succeed in filling the research service requirement of payback, it probably would be cheaper to cut out the payback requirement altogether and recover the costs needed now to administer payback.

If our nation wants to endorse higher education and training, then NRSA stipends should not be taxed. Senator Trent Lott (Mississippi) tried to make stipends nontaxable, but unfortunately this was cut out in conference. Many schools do not send 1099 forms to students, and the IRS may soon try to enforce taxation of stipends.

(3) Women and minorities: These really should not be linked together, as they represent very different problems.

Over 40 percent of the Ph.D.s produced in the life sciences are women, so they are not underrepresented at this stage. The difficulty occurs later when they are limited to a geographical area for job opportunities because of a spouse. Also, there is the problem of child care if they raise a family. Should we have more part-time jobs? NRSA awards can do little to solve these social problems.

Much has been done to try to improve minority recruitment. Predoctoral training grants require a proactive stance of the schools they fund. The MARC program tries to support the pool from which minority applicants will come. In addition, recent policy changes permit supplements for minority students supported by research grants. Finally, there is a new program of individual minority predoctoral fellowships. This started off at 100 fellowship awards, but dropped to 50 new fellowships in the second year of this program and less than 30 new starts in the third (current) year because a special budget had not been appropriated for this. The pool would justify funding this program at 50 new fellowships per year. Despite all these efforts, in the end many of the same forces drive minority students as majority students: the best students choose an M.D. over a Ph.D. because it offers a more secure job at a better salary.

(4) Strengthen NRSA quality training: Maintain the “above the line” non-trainee expenses allocated to predoctoral training grants, which often is used to support the graduate program seminar series,research day retreats, etc.

Good luck to your Committee on its undertaking of this review. I hope your report will be more intelligible than the previous one where the numbers were stated as FTEs rather than slots, and so were hard to interpret.

TABLE 1. Brown University Statistics of Ph.D. Programs

(I) All Biomedical Ph.D. Programs at Brown							
U.S. citizens/total applicants							
1985	1986	1987	1988	1989	1990	1991	1992
80/117	81/136	63/116	77/130	70/158	86/188	97/240	82/228
68%	60%	54%	59%	44%	46%	40%	36%
(II) Graduating Brown BioMed							
Undergraduates who go to Graduate School							
1985	1986	1987					
12%	9%	5%					

STATEMENT BY BARTON W. GIDDINGS

I am pleased to address this Committee on the training of biomedical and behavioral sciences researchers. My primary concern with respect to current training efforts is that many talented people do not choose careers in science because of formidable economic disincentives. No career path, except some medical specialties, requires more training than biomedical research. A Ph.D. in Biology at M.I.T. now averages approximately six years (some students take longer!), and postdoctoral research in the lab in which I work takes, on average, four years (and I have met many people in the field who need a second period of postdoctoral training). Together, this represents ten or more years of post-baccalaureate training, most of it at an extremely low salary, most or all of it with no health insurance or other benefits, and with no guarantee of a job or salary when the long training period ends. Do we really doubt what constitutes the "most significant challenge we face"?

I have enjoyed a wonderful scientific training experience as a graduate student in a prestigious laboratory at the Massachusetts Institute of Technology, but my own situation clearly illustrates the economic difficulties of this long training process: I am a sixth-year graduate student with perhaps one more year before finishing my Ph.D. My NRSA training grant provides $8,800 taxable salary per year. This amount is supplemented by $5,200 from my institution, for a total of $14,000 per year. Assuming that I, like the average graduate student in my department, work 60 to 70 hours per week, that puts my hourly wage at about four dollars per hour (about two-fifty per hour from the NRSA grant). Furthermore, I receive no employment benefits. I pay for health insurance for my family (wife and two children) out of my stipend at a cost of $2,808 (twenty percent of my total income). I receive no child care or other benefits.

I have heard some try to justify my small stipend with a variety of arguments, including the cost of educating graduate students (tuition) and the view that a graduate student is but a trainee, unworthy of more than a pittance. Neither of these arguments, however, addresses my concern that requiring scientific trainees to endure a very long period of training without adequate economic rewards discourages many from undertaking careers in research.

Many of my college friends majored in science. These people were the kids who loved science in high school, took Advanced Placement math and science classes, and were motivated to study science as undergraduates. But virtually all of these friends, though trained in science and engineering, chose careers in non-scientific fields such as law and business. I recognize that this observation is anecdotal. Nevertheless, it is obvious that career choices are governed by the economic laws of supply and demand: the higher the wage for a given job, the more people will be willing to do that job. My friends' career choices offered better monetary rewards and did not require the long period of economic deprivation demanded by science. Their choices reflect the values that our society apparently assigns to different types of work.

I also believe that these substantial economic difficulties constitute a continued obstacle to efforts to recruit more women and minorities to research. I have participated in a Whitehead Institute program in which local high school students, including a large number of female and minority students, attend a series of lectures and meet scientists at our research institute. When I talk to these students (who are among the most talented at their schools) about careers in research, the long training period and low salary are among their most frequently voiced concerns. Thus, while our efforts may convince these students that "science is neat," I am afraid that they, like my college friends described above

(who also thought "science is neat"), will be talent lost to science. The economic disincentives to research careers are great; the opportunities appear much better elsewhere.

I believe the most important step to strengthening the NRSA training grant is to ensure that it is economically fair. Graduate students should not be denied basic benefits, such as health insurance, including coverage for their families. Graduate students should be guaranteed a fair wage, commensurate with their years of experience, for their countless hours of toil. A reasonable income is especially important because many of the best training opportunities are in expensive cities such as New York, Boston, and San Francisco, but students and post-docs receiving small stipends and salaries often find it difficult to live comfortably and safely in these cities. Furthermore, several graduate students I know take on additional responsibilities (e.g., teaching classes) to earn extra money. These duties detract from their research training.

I do not believe that there is anything we can do to motivate young people to choose scientific careers more strongly than can their own desires to explore previously unanswered questions. What we must do, then, is to remove the economic hardships of the long training periods required for careers in the sciences.

STATEMENT BY LEE GOLDMAN, M.D.

As you presumably know, I have been the principal investigator on one of the few institutional NRSAs awarded for primary care disciplines, and this award has recently been renewed for another five years at twice its additional size. I am also a listed faculty member on other institutional NRSAs in cardiology, health services research, and AIDS, and I have precepted several individual NRSAs. While this prior experience undoubtedly biases my viewpoint, it has also provided me with a substantial opportunity to observe the virtues of the NRSA program.

At the outset, I should emphasize that I fully support institutional NRSAs, because they provide an opportunity for bright young trainees to begin research without being forced to commit prematurely to a detailed project. It is important to retain a balance between institutional NRSAs, which by definition attract researchers at a less differentiated phase, and individual NRSAs, which require substantially more preparation by the applicant but make it difficult for individuals to begin research at the postdoctoral level. In response to your specific questions:

1. *I believe that the most serious challenge that we face for maintaining an adequate supply of qualified scientists in health research is to find the appropriate balance between security and competitiveness.* On the one hand, careers in health sciences are and should be subject to the classic pressures of social Darwinism. Limited research funds should be targeted selectively to the most promising and productive researchers and fields. Although such a research "pyramid" will not optimize the job security of health care researchers, any other system would represent a relative waste of limited resources.

Nevertheless, this social Darwinistic pyramid will be counterproductive if successful researchers do not have adequate assurances at each career stage that they will be successful and progress to subsequent stages.

2. *Our growing understanding of training and mentoring suggest several specific improvements to strengthen NRSAs in the future.* First, many programs incorrectly assume that the apprenticeship model is the ideal way to train a researcher. In this model, a trainee commits to an individual laboratory and learns the techniques of the laboratory director. If the training program is successful, the trainee is then prepared to continue to work in the mentor's laboratory or to recreate a similar laboratory elsewhere. This approach can be contrasted to most Ph.D. programs, in which young trainees learn a broad base of up-to-date scientific skills in a structured curriculum before committing to a focused research project. The Ph.D. trainee is much better prepared to integrate several scientific disciplines and to enhance, not just reproduce, the work of the mentor. I would suggest that all NRSA programs be required to have more structured and formal coursework, preferably in conjunction with basic scientists outside the clinical department, to teach trainees the fundamentals of biomedical science and the full range of quantitative and other skills that are required for research. Ideally, an institutional NRSA would have two tracks: one to emphasize basic biomedical laboratory science for the "wet lab" researcher, and the other to emphasize quantitative and

social sciences for the trainee who plans to pursue patient-oriented, outcomes research.

Second, I believe that the mentorship system should be more formal and structured. For example, NRSA renewals might require submission of a 250 word evaluation of the progress of each individual trainee, in addition to the usual compilation of abstracts and presentations. This formal evaluation, which the program will be required to share with the trainee, would help the trainee and would serve as a "reality check" for both the program and the sponsoring agency.

3. *Our primary care NRSA has had no difficulty attracting top quality female applicants, but minority applicants have been much less plentiful.* One of the major problems is that most career decisions have occurred at an earlier phase, so that the ability of NRSA fellowships to alter plans is limited. At the current time, minority recruitment efforts of individual programs simply foster competition to recruit from among the small pool of available applicants. Unless the pool is expanded, minority recruitment efforts are simply "reshuffling the deck." Thus, I believe that a coordinated effort, led by the NIH and other similar organizations, must attempt to enrich the pool of female and minority trainees who are interested in research careers. For example, the principal investigator of each institutional NRSA might be required (and funded) to attend one meeting during every five year cycle specifically to recruit female and minority medical students or housestaff into research careers.
4. *As noted above, I would suggest a strengthening of the requirements for formal coursework in state-of-the-art scientific disciplines broadly relevant to medical research.* As a result, trainees would be better prepared to integrate various scientific approaches and to learn new approaches. I am also concerned that the current institutional NRSA environment may sometimes be too laissez-faire, so that trainees do not receive clear feedback regarding their research progress. A more formal evaluation requirement, shared both with the trainee and with the funding agency, could provide an explicit set of expectations as well as indications as to whether these expectations are being met. Programs and individual trainees could then be evaluated not only on whether expectations were met, but also on whether the program directors have established appropriate expectations.
5. *I agree that a variety of opportunities are emerging for research scientists in industry and other new settings.* However, such opportunities will only increase the need for entry-level training, such as is provided by NRSA programs.

Emerging research opportunities will make it increasingly necessary for trainees to have broad-based scientific training, in addition to their precepted research experience. NRSA programs must be designed to train the full range of biomedical and healthcare scientists who will be needed for the future. As patient-oriented outcomes research and research at the interface between laboratory discoveries and clinical applications become more important, NRSA programs must include training in these skills as well as basic "wet lab" skills.

STATEMENT BY RICHARD J. GRAND, M.D.

I am extremely grateful for the opportunity to share some of my ideas regarding biomedical research training with so many distinguished colleagues. The challenges are great, and, regretfully, the national political agenda seems unpropitious.

How to continue to fund training in biomedical sciences?

Established programs for the support of training in biomedical research, such as the Research Training and Career Development Programs at the National Institutes of Health, represent valuable resources which must be preserved and enriched. The Institutional and Individual National Research Service Awards are currently virtually the only available mechanisms for research training of M.D. and pre- and post-doctoral Ph.D. young investigators. Even these Awards have unsolved problems; nevertheless, their loss would produce incalculable damage to progress in the biomedical sciences. Current problems with these awards are as follows:

1. NRSA stipends have not kept pace with the salaries offered M.D.s moving from residency into full-time practice, or Ph.D.s recruited into industry. With the debt load on today's residents, there need to be financial incentives to offset the temptations of

practice. Future commitment to research careers needs to be rewarded early.

2. The number of NRSAs funded annually are too few to secure an adequate pool of young investigators.
3. After graduation from a training program, competition for "bridge" grants, the CIA and the FIRST awards, is keen, and inadequate numbers of these are offered.

Investing in the scientific training of young investigators seems to me to be a national priority of high value to society.

How to maintain an adequate pool of qualified scientists?

The most significant challenge to an adequate supply of qualified scientists is the maintenance of an adequate pool of M.D. physician scientists. During my term as Chairman of the GMA-2 Study Section at NIH (and my experience as an ad hoc reviewer in the last cycle of this study section), it has become apparent that a majority of new and competing RO1 applications is submitted by Ph.D. applicants. Furthermore, the number of M.D. graduates from medical school interested in careers in academic medicine is shrinking, more in some specialties (e.g. pediatrics) than others. The reasons for this are obvious:

a) increasing financial burdens on medical students
b) the view that biomedical research is a risky enterprise in times of inadequate support
c) the rigors of and competition in academic careers

The joys of academic medicine can only be transmitted by enthusiastic faculty and innovative programs.

Improvements in the National Research Service Awards Program, directed at M.D. candidates and young physicians in training might begin to stimulate interest in academic careers. My colleagues, Dr. Philip Rosoff and Dr. Jane Schaller, and I have been discussing a model program which may be of interest to you.

Under the auspices of the NRSA Program, medical schools could compete for small grants to support short and longer term research experiences for medical students.

We would suggest a one year research support program during which the student would receive:

- credit for research performed
- living expenses
- support for interest due on loans, and
- a modest amount for lab fees

Shorter "summer quarter" research experiences could be supported pro-rata. In the setting of a medical school honors program, this would be an important mechanism for drawing young people into laboratories. I should state that we have also considered developing a similar program for residents, in order to continue to rekindle their interest in research careers. I realize that this would require an infusion of new dollars into the NRSA program, but I doubt innovative change can be accomplished with current dollars.

In order to improve effectiveness of the NRSA programs for minority groups, an early intervention program is necessary. Specific numbers of awards could be targeted for this area as I have already described.

Can anything be learned by the way in which we train Ph.D.s in science?

One of the differences between M.D. training and Ph.D. training is that M.D. training is often principal investigator generated, while Ph.D. training is discipline generated and involves core curriculum as well as research. I think that the overall quality of the training provided to M.D.s can be assessed by the "use" of the trainees. For example, if in a given training grant, all of the trainees work for a single mentor, I would be concerned that the trainees were being "enslaved" rather than educated. It seems to me unlikely that all trainees in a single program would have the same research interests.

Secondly, for M.D. investigators, a core curriculum, which is mandatory and offered on an annual basis, could help to supplement course material in specific areas. The core curriculum would contain a focus on research methodology, biostatistics, study design, scientific writing, and the NIH/NSF Award Programs. The topic of scientific integrity could be included in the core curriculum, but it is already mandated in the NRSA Program. In the Department of Pediatrics at Tufts University School of Medicine, we have offered such a course for several years, and it has

been highly regarded by our trainees (and even junior faculty).

Finally, for Ph.D. trainees in biomedical human disease would be desirable. An example of that is the predoctoral program directed by Dr. Irwin Arias at Tufts University School of Medicine, about which you have already heard. In this program, Ph.D. trainees take a course in human pathobiology, which is focused on integrating basic research and human disease. This is an enormously successful program and was described by Dr. Arias in a recent article in the New England Journal of Medicine.

Summary

A crisis exists in the support of training for biomedical research, which needs urgent attention. This includes:

- continued support of biomedical research
- continued support of the NRS A program
- innovative methods for bringing young people into biomedical research
- new mechanisms for "bridge" support from NRSA to first "independent" funding
- expanding the pool of young people going into research careers, including innovative ways of recruiting minority trainees
- developing curricula for M.D. trainees in biomedical science
- ascertainment that trainees' needs drive training programs, not mentors' needs
- on-going dialogues regarding biomedical science as a national priority

STATEMENT BY ADA K. JACOX, Ph.D, R.N., F.A.A.N.

The American Nurses Association (ANA) is pleased to have the opportunity to discuss with the Committee the need for biomedical and behavioral research personnel. There is a tremendous need for reliable and timely estimates of supply and demand of all disciplines involved in biomedical and behavioral research. Nurse scientists conduct research in many diverse areas, and increasingly integrate the bio-psycho-social sciences into the nursing hypotheses being tested. New training programs are being developed that build on collaboration among disciplines, linking the biological/molecular and behavioral sciences with nursing research. The complexity of health care problems and the need for evaluation of methods and costs of delivering health care services, will also require increased collaboration among nurses and health services researchers. Support for the preparation of future nurse scientists from the NRSA program is critical to the establishment of the cadre of nurses with the skills and resources required to contribute to improving our national health care environment.

There are several ways to estimate the current supply of doctorally prepared nurses. The 1992 National Sample Survey of Registered Nurses, conducted by the Division of Nursing, HRSA, estimates that there were 11,284 registered nurses with doctorates in 1992. This represents only 0.5 percent of the total registered nurse population (Division of Nursing, March, 1992). The American Association of Colleges of Nursing (AACN) reports enrollment and graduations in baccalaureate and graduate programs in nursing. Table 1 provides information on trends in enrollments and graduations over the last five years in a cohort of 53 schools of nursing with doctoral programs. Both enrollment and graduations show significant steady increases since 1988. In the Fall of 1992, there were a total of 2,797 students enrolled in the 54 programs offering nursing doctoral degrees; 57 percent were enrolled on a part-time basis. It is important to note that over half of the enrolled doctoral students attend on a part-time basis. Existing sources of financial support for predoctoral training are very limited, and many registered nurses find it essential to work full time while pursuing doctoral study.

There is difficulty in estimating the supply of nurses with doctorates partly because an unknown number of nurses graduate each year from programs in related fields such as psychology or epidemiology, and these graduates are not tracked in any systematic way. The 1992 National Sample Survey estimates that there are 7,000 registered nurses with doctorates in related fields (Division of Nursing, March, 1992).

Even with the increase in numbers of doctorally prepared nurses, the gap between supply and demand remains large. It is important to note employment trends of doctorally prepared nurses as related to demand in service settings as well as in academia. The 1984 Sample Survey reported that 9.3 percent of doctorally prepared nurses worked in hospitals (Moses, 1986). In 1988, the estimate was for 80 percent of nurses with doctorates employed as faculty, 14 percent in hospitals, and 6 percent in other areas. The latest sample survey estimates that in 1992, 63.4 percent of employed nurses with doctorates were employed in nursing education, 18.5 percent were employed in hospital settings, and the remainder were employed in other categories. Many more nurses employed in hospitals and other service settings are in research related positions conducting clinical investigations related to quality of care, effectiveness of clinical therapeutics, and ethics and clinical decision making.

The most recent AACN data indicates that only 59.7 percent of nurse faculty members who have full-time appointments in schools of nursing offering doctoral programs hold earned doctorates. For institutions offering only baccalaureate level programs, the figure is 24.7 percent (Bednash, 1993). It is clear that nursing staff has a great distance to go before its academic faculty are fully prepared educationally. Another concern is the age of nursing school faculty. For the 7,750 full- time faculty reporting age data, the mean age is 47.2 years; for faculty in schools with doctoral programs the mean age is 49.2. AACN data on faculty race and ethnicity indicate that 45.1 percent of only 679 minority faculty in schools of nursing have earned doctorates (Bednash, 1993). Research training for minority nurses clearly needs to be a priority.

Most of the projections of need for nurses with doctoral preparation have focused on predoctoral training and have not addressed the needs of nurses with a basic research preparation to build a program of research. The ANA Council of Nurse Researchers has advocated for more resources for postdoctoral positions so that individuals can receive the mentoring needed as they develop a research track record (ANA, 1985). Because there is such a tremendous demand for nurses with doctorates in schools of nursing, faculty have many other teaching responsibilities and often delay developing an active research program. At the same time, the competition for research funding is very keen, requiring previous experience and pilot work if applicants are to be successful. Twenty schools of nursing received BRSG support in 1991, the final year of the BRSG program, and were able to assist faculty with pilot monies for initiating research projects. Fewer than 50 nurses per year are supported by the NRSA program for postdoctoral study. The RWJ Foundation funded a clinical nurse scholars program in which they granted two years of support for post-doctoral study. This program, begun in 1982 to assist faculty in developing their research careers, was phased out in 1991. There continues to be a need to enhance the research skills of nurses through postdoctoral study as well as additional opportunities to build new skills at the mid career level.

An additional source of information regarding need for doctorally prepared nurses is the Institute of Medicine Committee on National Needs for Biomedical and Behavioral Research Personnel. The 1985 Institute of Medicine Report on Research Personnel noted that “the low rate of unemployment of nurses with doctorates, the low percentage of nurse faculty members with doctorates, and the rapid growth in the number of doctoral programs in nursing lead the Committee to conclude, even in the absence of numerical projections, that there is and will continue to be unfilled demand for researchers in this area” (NAS, 1985). The report recommended NRSA support of 320 nurses in research training by 1991.

Research training and career development are a major component of the long-range plan of the National Center for Nursing Research (NCNR) and have consistently received strong interest from Congress. The projections developed by the NAS have been critical in developing NCNR research training programs. Because of budget constraints, NCNR has been unable to follow the NAS recommendations. NCNR supported a total of 269 trainees in 1991 and a total of 261 trainees in 1992. Only 16 percent of trainees funded were in postdoctoral training. It is estimated that an additional $2.2 million would be required to bring the training program in line with the 1985 NAS recommendations. In the 1989-1990 Biennial Report to the Congress, The National Advisory Council for Nursing Research projected the need for 362 NRSA supported positions by 1995. They also included a recommendation of 50 research career awards by 1995 (a mid career award for investigators). In order to implement this recommendation, $6.8 million would be needed for the NRSA program and $2.2 million would be required for the mid careers program.

Table 1. Five-Year Doctoral Enrollment and Graduation Changes in the Same 53 Schools by Region and Student Status.

	YEAR					CHANGE PER YEAR	SIGNIFICANCE
	1988-89	1989-90	1990-91	1991-92	1992-93		
	NUMBER OF STUDENTS	NUMBER OF STUDENTS	NUMBER OF STUDENTS	NUMBER OF STUDENTS	NUMBER OF STUDENTS	NUMBER OF STUDENTS	P-VALUE
NORTH ATLANTIC							
PUBLIC							
FULL-TIME	25	21	25	22	20	-1	0.27
PART-TIME	7	36	45	64	61	14	0.02
GRADUATES	0	0	2	1	7	1	0.09
SECULAR							
FULL-TIME	119	113	138	114	222	21	0.18
PART-TIME	320	300	359	479	333	20	0.44
GRADUATES	47	92	55	60	70	1	0.84
RELIGIOUS							
FULL-TIME	27	39	41	49	48	5	0.02
PART-TIME	45	35	37	32	35	- 2	0.15
GRADUATES	10	15	10	11	12	0	1.0
MIDWEST							
PUBLIC							
FULL-TIME	201	195	205	204	222	5	0.10
PART-TIME	205	247	264	293	328	29	0.001
GRADUATES	44	43	45	63	65	6	0.04
SECULAR							
FULL-TIME	36	52	64	37	49	1	0.81
PART-TIME	54	100	108	89	75	3	0.71
GRADUATES	16	16	16	24	21	2	0.13
RELIGIOUS							
FULL-TIME	.	2	7	17	20	6	0.02
PART-TIME	.	5	18	21	30	8	0.03
GRADUATES	.	.	.	.	.	.	.
SOUTH							
PUBLIC							
FULL-TIME	310	274	312	337	296	3	0.70
PART-TIME	455	536	577	501	587	23	0.22
GRADUATES	83	97	107	125	118	10	0.02
SECULAR							
FULL-TIME	.	.	.	.	.	.	.
PART-TIME	.	.	.	.	.	.	.
GRADUATES	.	.	.	.	.	.	.
RELIGIOUS							
FULL-TIME	.	.	.	.	.	.	.
PART-TIME	.	.	.	.	.	.	.
GRADUATES	.	.	.	.	.	.	.
WEST							
PUBLIC							
FULL-TIME	239	283	314	283	295	11	0.24
PART-TIME	73	85	77	105	116	11	0.03
GRADUATES	32	54	39	48	71	7	0.14
SECULAR							
FULL-TIME	.	.	.	.	.	.	.
PART-TIME	.	.	.	.	.	.	.
GRADUATES	.	.	.	.	.	.	.
RELIGIOUS							
FULL-TIME	12	5	0	4	7	-1	0.51
PART-TIME	27	44	38	29	30	-1	0.75
GRADUATES	0	1	13	15	5	2	0.33
TOTAL							
FULL-TIME	969	984	1,106	1,067	1,179	50	0.03
PART-TIME	1,186	1,388	1,523	1,613	1,595	104	0.02
TOTAL	2,155	2,372	2,629	2,680	2,774	.	.
GRADUATES	232	318	287	347	369	30	0.040

Source: American Association of Colleges of Nursing, *Institutional Data Systems* 1992-93.

The future of cost- effective, high quality and accessible health care for the American people requires excellence in nursing practice, which in turn depends on knowledge established through research. The small proportion of nurses with doctoral preparation as investigators, in contrast with the large demand for more researchers to generate nursing knowledge, necessitates a plan to revitalize funding for nursing research training.

Specific Recommendations:

- Funding for nursing research training should triple in the next three years if we are to have an adequate cadre of investigators trained to work in academia as well as service settings who can link new scientific breakthroughs in the biological and behavioral sciences with the ever changing complex clinical problems.
- The mix of predoctoral and postdoctoral awards should remain fluid as new developments in science and the needs of specific areas of science dictate, be it state of the art molecular technology or new behavioral techniques. The need for nursing research to focus resources in postdoctoral training is critical; at the same time there is a continuing need to increase the number of nurses receiving predoctoral training.
- Institutional training awards should be encouraged where there are well developed interdisciplinary programs of research. Trainees should be exposed to a variety of approaches to a particular problem, and encouraged to explore the behavioral and biological underpinnings of complex health problems. Trainees should be able to study with multidisciplinary teams. Nurse trainees should be included in the institutional training grants funded in the other biological and behavioral sciences.
- Training mechanisms need to be restructured to increase flexibility and access to scientific careers, especially for women and minorities who frequently have other responsibilities and begin their studies later in life.
- There should be a continued effort to recruit minority nurses into research careers. Linkages between minority institutions, organizations, and research intensive institutions should be developed.
- Stipends for predoctoral NRSAs and postdoctoral positions should be increased. Current dollars are below the poverty level for predoctoral NRSA, and the stipends for postdoctoral positions are not competitive with beginning faculty salaries.
- Various mid-career training mechanisms to accommodate shifts in scientific focus and new technologies should be encouraged. Today's scientific breakthroughs require opportunities to learn new technologies as well as to undertake novel, innovative science that crosses traditional disciplines.

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STATEMENT BY ELIZABETH W. JONES, Ph.D.

I will comment on four issues: the influence of early research exposure and experience in awakening interest in biomedical research, the effectiveness of such programs in recruiting women and minority students into a research path, the cost effectiveness of this training mode, and the inadequacy of the funds available for such training.

At Carnegie Mellon University (CMU), nearly 90 percent of students graduating in Biological Sciences carry out independent research at some time in their education. Some do research for the entire four years, some only one; the average is probably two years. Career paths of our graduates split about equally into thirds: to graduate school, to medical school (about a third in M.D./Ph.D. programs), and to jobs. About a third of this last group goes to medical or graduate school later. Thus about half of our graduates enter careers in biomedical research. This is a large fraction. It probably reflects to some degree a pattern of self selection on the part of students, for we are not known as a premed school, have no premedical curriculum per se, and have stringent hard science requirements. In addition, these students often have received previous exposure to good science in the form of summer programs like the Pennsylvania Governor's Schools for the Sciences held at CMU and Penn State for high school juniors, providing some basis for the self selection.

Regardless of the element of self selection, we think that the undergraduate research experience is a very important element in the decision to embark on a research career, for it allows an informed decision to be made. I repeat the outcome: about 50 percent of our graduates engage in careers in biomedical research.

Our departmental faculty of 18 has a long standing and serious commitment to undergraduate research. Typically about 60 students do research each term, about 55 during the summer, and the mean and median number of undergraduate students/lab is about 3. A recent search of the two page NSF/NIH bios of our faculty members revealed 25 papers with undergraduate authors and 22 undergraduate authors.

Our summer research students include CMU students and 10 non-CMU students participating in an NSF-REU program. During the past four years of this NSF-REU program, 68 percent of the participants have been from liberal arts colleges or colleges with large minority enrollments, 62 percent have been women, and 24 percent have been minority students. Of the participants who have already received bachelor's degrees, 60 percent have entered Ph.D. programs, 10 percent M.D./Ph.D. programs, 10 percent M.D. programs. Of the remaining 20 percent, nearly all intend to apply to graduate or medical school in the near future.

Although it is impossible to disentangle the element of self selection from these data, the fact remains that a very large fraction of students who participate in undergraduate research programs end up in biomedical research careers. They are able to make the commitment knowing in advance that they enjoy doing research and are good at it.

What is the cost of providing this opportunity for an enlightened decision? The NSF-REU grant that supports our program provides $5,000/student. This provides a $2,500 summer stipend, a housing and travel allowance, some funds for instruction and supplies, and limited overhead. By contrast, a naive student without research experience who enters graduate school will cost $20-30,000/year. Some fraction of those will withdraw, a very costly route to a decision. And it's impossible to estimate the fraction of naive students who never realize that they would and could have enjoyed research careers.

How do we at Carnegie Mellon support the research activities of undergraduates? Using last summer as an example, 10 students were supported by an NSF-REU and 13 by a grant from the Howard Hughes Foundation. The remaining 31 were supported on research grants or by work study funds from the state of Pennsylvania. During the fall term of 1992, 22 students received course credit for research. The remaining 37 students were supported by funds from research grants, the Hughes grant, or work study funds from the Pennsylvania or U.S. government.

Are the funds available adequate to this purpose? Among Carnegie Mellon biology students, we have more applicants than we can afford to pay (or have room for). On a national level I believe the problem to be much more acute. For our NSF-REU program, for the years 1991-1993, we had 154, 208, and 297 applicants respectively for 10 places. Obviously many students apply to more than one program. However, we have found that we must accept students very carefully, for about 75 percent of the students we accept will matriculate. By contrast, rates of matriculation

among accepted graduate students are 25-35 percent. Although I'd love to think that our 75 percent matriculation rate in our NSF-REU is due to the excellence of our program, realistically one must infer that there are too few programs and places for the number of students who are interested.

The conclusions I hope you will draw from the information I have presented are: first, that undergraduate research programs are successful in stimulating interest in and commitment to biomedical research careers; second, that funded summer programs provide the opportunity for minority students and students from liberal arts colleges to gain access to research opportunities; third, that funded undergraduate research programs are cost effective in allowing informed choice; and fourth, that funds to support these activities are inadequate.

STATEMENT BY JAMES M. JONES, Ph.D.

Thank you for the opportunity to present some oral comments regarding ways to strengthen the National Research Service Award program. I am Dr. James M. Jones, Director of the American Psychological Association (APA) Minority Fellowship Program, and Professor of Psychology at the University of Delaware. I am here on behalf of Dr. Wayne Camara, Associate Executive Director for Science at APA, who had to be in California today. I have directed the APA Program since 1977. We have three training grants, two of which fall under the NRSA aegis. The first is for predoctoral research in non-clinical fields of psychology; the second is for pre and postdoctoral research in neuroscience. The third grant is for training in clinical, counseling and school psychology. While most of the recipients of this grant have aspirations for health service careers, many do pursue academic research careers. You have copies of the written comments submitted by Dr. Camara, and I would be happy to respond to any specific questions raised by that correspondence. For my comments today, I wish to focus on four main points:

1) *The recommendation of the Committee to remove NRSA support for clinical training in psychology*
2) *The desirability of increased support for ethnic minority researchers*
3) *Importance of Behavioral Research in Solving Human Problems*
4) *The need to consider the programmatic nature of support across the levels of training, and the need for flexibility in consideration of different training areas*

Continued Support for Clinical Research Training

The recommendation to reduce support for clinical training fails to consider the nature of the field, and the important role of clinical research in other areas for which the Committee has made recommendations to increase support. The recommendation, stemming it seems from concern about the growing number of Ph.D. and PSY.D. degrees among psychologists with a non-research career objective of health service fields, obscures the fact that there continues to be a substantial community of clinical research training programs in psychology and students with academic/research career aspirations. There are over 80,000 Doctoral members of the American Psychological Association, of whom about 45,000 are classified as service providers. Of this number, it is a good estimate that about 25-30 percent (10,000-15,000) are in primarily academic/research careers. To make a blanket claim that clinical psychology trainees do not do research is unwarranted. Furthermore, the fact is that the Committee's recommendations for increases in support for clinical sciences and health services research, indeed biomedical research begs the question of clinical research training support. Clinical researchers contribute heavily to psychophysiological research, health psychology and behavioral medicine, behavioral aspects of mental health and the like. Many of these researchers work in not only academic psychology settings, but in departments of psychiatry, hospitals, and private health service organizations. It is important to recognize the institutions, research orientations and contributions of clinical research to the overall mission of biomedical and behavioral science research. Funding approaches would do better to refine the identification and support of such researchers, rather than, simply reach the blanket conclusion that "clinical psychology" is primarily service oriented and therefore beyond the purview of NRSA support.

Continued Support for Ethnic Minorities in Biomedical and Behavioral Research

In our cover letter we made mention of the effectiveness of awarding training grants to National Associations to provide an integrated and highly visible effort on behalf of ethnic minority trainees. We also argued that summer research support at the baccalaureate level pays very positive dividends, and should be encouraged. I would like to add here that one of the main problems with recruiting minorities into the research pipeline is that these careers do not have the visibility at an early stage of formulating career goals. Minority students with behavioral and biomedical interests more typically consider "helping" professions as the avenue to express those career aspirations. When they learn how research, basic and applied, enhances the understanding of problems they seek to address, they develop a new appreciation for research as a component of any related career. I have seen this happen with students who come to the University of Delaware for our NRSA sponsored summer research program. Once they learn that there are major scientific gaps in our understanding of problems in ethnic minority populations, and that research approaches can substantially help to chart enhanced knowledge and courses of intervention, they profess to a renewed interest in research. These in-depth experiences and ongoing mentoring opportunities are among the most important contributions to entry into the pipeline for ethnic minority researchers. The earlier this happens the better, but it must be back-stopped with consistent and substantial encouragement and resources as one moves up the career training ladder. The set of programs of NIH from MARC and MBRS (Minority Biomedical Research Support) (at both individual and institutional levels) through post-doctoral programs seems to be a reasonable way to go. The proposal to do more comprehensive evaluation of these programs is a good one.

Importance of Behavioral Research in Solving Human Problems

It is APA's assertion that research from the behavioral sciences is vital if we are to address many of our most pressing national problems. Behavioral science research is vital in developing new technologies and designing interfaces between systems, technologies, and human resources. Behavioral science research is also vital in developing new theories of job performance and teaming that will lead to increased international competitiveness through the redesign of education and learning in our schools as well as a re-conceptualization of work and performance in organizations. And behavioral science research is essential in addressing nearly all of our pressing national needs which range from disease prevention to the development and maintenance of the nation's scientific talent, to improving the quality of life for our increasingly elderly population. The contributions of behavioral science have been increasingly recognized by the scientific community and given an increasingly important voice in addressing our nation's most urgent problems. As evidence I point to the establishment of a separate directorate for Social, Behavioral, and Economic Sciences in the National Science Foundation, and the centrality of behavior to nearly all of the needs and major goals listed throughout the National Institutes of Health's Strategic Plan. Scientists and policymakers have increasingly recognized the importance of inter-disciplinary research in addressing our nation's problems. Behavioral science research, which incorporates cognitive science, neuroscience, ergonomics, clinical research, development, social cognition, organizational behavior, etc., is essential for a comprehensive scientific inquiry of issues facing our nation in the next century. The nation's scientific base requires a strong and vibrant behavioral science capacity, yet support for psychological research training has decreased.

Need for Flexibility in Administration of the NRSA.

Finally, we commented on the need for flexibility in our previously submitted materials. We are aware that psychologists possess a wide range of skills that are relevant, indeed central, to the research mission of NIH. Those skills are cultivated in many different settings, and demonstrated in an equally broad arena. The idea that behavior underlies many health and mental health problems has been widely demonstrated. That these problems exist across contexts and settings, and throughout the life-span broadly implicate the full range of psychological expertise. Thus,we strongly urge that you consider the skills that psychologists have, where they can obtain training to enhance those skills, and how the funding support available through NRSA may be most efficiently used

to create this talent pool of behavioral and biomedical scientists. As we noted, postdoctoral support may be more applicable in more biomedically oriented subdisciplines, such as psychobiology and neuroscience, than in other areas such as developmental or social psychology. Moreover, it may be a very good use of resources to consider postdoctoral support for minorities as well. We recently added a postdoctoral component to our APA Neuroscience program and had 30 applicants from which to choose 6 postdoctoral recipients. In advertising opportunities for the Minority Research Supplements programs, there were many respondents who expressed interest in advancing their research skills and specific techniques at the postdoctoral level. It seems that the promise of the minority supplements as a training opportunity, is not fully realized. It is our belief that research careers in biomedical and behavioral science fields should show growth over the next decade, and the most important role of NRSA is to provide leadership and vision in providing training support to meet the supply of well trained and diverse scientists that are and will be needed. To this end, we feel that pipeline is probably the single most important issue to be addressed. We also recognize that the earlier you introduce programs, the less efficient they become in producing Ph.D.s at the other end. That is why a carefully balanced, efficient program is desirable. Perhaps the plans for evaluations of these programs will prove helpful in charting a reasonable course of action. Psychology has an important role to play in defining the needs and opportunities for training in the various fields of psychology. It has to take responsibility for increasing the rate with which new graduate students seek primarily research careers as well. Given the massive decline in predoctoral training support over the past decade, we feel that substantial assistance is needed to provide the funding base to support these efforts. We feel that training in psychological research is important and look forward to helping in any way we can.

STATEMENT BY HOMAYOUN KAZEMI, M.D.

I am Homayoun Kazemi, a Professor of Medicine at Harvard Medical School and Chief of the Pulmonary and Critical Care Unit at the Massachusetts General Hospital. I have directed a research training program in pulmonary pathophysiology for the past twenty five years. I very much appreciate the opportunity to present my views on the subject of the need for biomedical research personnel. Let me begin by stating that I am cognizant of the fact that biomedical research and medicine at large are undergoing major changes at the moment, and future trends in health care delivery and medical research are somewhat uncertain. However, regardless of the uncertainty, one thing that has been preeminent in American medical science has been the important contributions made to medicine at large by biomedical investigation. This has taken place primarily in medical schools and teaching hospitals and has through the years provided the basis for the excellence of medicine that is available in this country and, furthermore, underlies the prominence of American biomedical research in the world. This enterprise is now being threatened because of policies that bear directly on training of individuals in biomedical sciences, particularly those with an M.D. degree who enter research from a clinical perspective. If one were to point to major discoveries in medicine in the past five to six decades, one thing stands out: most discoveries were made at the time that the specific issue was not being investigated in the given laboratory, but came about by serendipity. It is the prepared mind that seizes the moment and, therefore, it is in this light that we need to address the necessity to continue to have a strong biomedical research community and to allow investigators to follow their lines of thought without being encumbered by too many restrictions in their research. To achieve our goals, it is important to have a continuing supply of young, energetic, and dedicated investigators who enter biomedical research for the rewards of discovery and for the contributions it makes to health care at large and to scholarship.

Having interviewed a number of applicants to medical school, to residency programs, and to our fellowship training program, I am impressed by the caliber of individuals who are electing to go into biomedical research. They are an extremely dedicated group of individuals of high intellectual achievement and integrity who will inevitably contribute to the advancement of medicine. In order to continue to draw this pool of individuals into biomedical research and at the same time allow them enough latitude to pursue their research and also be adequately compensated financially, a number of issues need to be addressed. If we accept the premise that biomedical research is essential for the well-being of our medical system and

necessary the for advancement of knowledge, then the following suggestions seem relevant.

1. *The most significant challenge that we face today in the United States for maintaining an adequate supply of qualified scientists relates to appropriate long-term funding*. It is very discouraging for young investigators to realize that stable funding is hard to come by, the struggle for it is enormous and the rewards are relatively modest. It is essential for the nation to establish a stable biomedical research support system and training and not have it fluctuate from year to year. It is important to pay individuals entering biomedical research at levels that are commensurate with the cost of living and that their incomes compare favorably with incomes of those in the same age group who go into law or business.

Research training takes anywhere from two to five years as a fellow. During that time, the message that the leaders have to impart to the trainees is that the future is bright, that discovery is rewarding in itself and that their work will be appreciated by the community at large. However, in this setting, we need to be cognizant of the financial needs of these individuals and their financial security. This is particularly true for those with an M.D. degree who finish medical school with significant debt and who do not look at biomedical research as an avenue where they can generate adequate funds to take care of their families as well as their debts. For example, at Harvard Medical School in the graduating class of 1992 last year, there were 107 students out of a total of 160 that had a mean debt of $51,438. Some 57 students were in debt in excess of $50,000 and 8 had debts of over $90,000. I believe we should pay them more and we should establish policies that allow better long-term funding than has been the case at the NIH in the past decade. If we do not do this, then we will lose the scientific primacy of the United States, and in the long run, our biomedical research endeavor will become totally commercialized, and science for the sake of science will no longer be performed by anyone.

2. *As far as the National Research Service Awards (NRSA) are concerned, adequate pay for the young investigator is a major factor, particularly those with the M.D. degree who enter research careers, because of the debt that many of these individuals have*. The current application for NRSA support as well as for research grant support is cumbersome; it occupies a great deal of time, and in many instances repeated applications are necessary before funding takes place. These are all discouraging for the young investigator. The peer review system has served a useful function through the years, but one wonders whether it continues to be as effective now as it has been in the past and whether more senior investigators should not be picked on the basis of their scientific achievements in the past and given a certain amount of financial support where they can continue with their work but also directly help with training of new investigators.
3. *Recruiting women and minorities into scientific careers is of high priority, and NIH has taken steps to help*. For it to work, minorities need to be introduced to science early. It is essential to strengthen and expand research training programs for college and high school students, to bring the students into research laboratories for a few months at a time to appreciate what biomedical research is, and then encourage their careers in sciences in college and medical school. The NRSA program could offer specific training to predoctoral students not only at the medical school level but also at the college and high school level, and thus increase the pool of minority candidates. One of the major drawbacks in not being able to bring investigators from minority groups into biomedical sciences is the lack of role models. Basically, we need better role models, more of them, and more money specifically put aside for the purpose of training women and minorities in biomedical sciences.
4. *The NRSA training programs have by and large achieved their goals*. For the training programs in clinical subspecialties, however, the problem that has arisen is that, on one side of the equation, the various specialty boards are requiring more and more time in clinical subspecialty training and documentation of specific technical expertise. At the same time the research training grants are suggesting that no clinical training be performed during research time. This inevitably creates conflicts for all programs. I believe it would be useful for the government to accept the fact that we need a number of sub-specialists who have both clinical expertise and research training, and that the two are complementary and not contradictory. The current guidelines from the NIH on NRSA programs and those put forth by the various subspecialty boards are in direct conflict. This causes a great deal of confusion amongst applicants and program directors.

Streamlining these guidelines would be of enormous help, and also it would be useful to have a dialogue between the NIH and the various subspecialty boards so there is a better understanding of what the aims of the two are and how the two can come together to provide a meaningful national program which will be helpful in creating biomedical investigators who can participate both in clinical research and in basic research.

STATEMENT BY GEORGE A. KIMMICH, PH.D.

Most graduate training programs in the biological sciences at the University of Rochester are offered through the School of Medicine and Dentistry. The School offers Ph.D. programs in Anatomy, Biochemistry, Biophysics, Genetics, Microbiology, Neuroscience, Pathology, Physiology, Pharmacology, and Toxicology. The Ph.D. in Biology is offered through the College of Arts and Science which is immediately adjacent to the Medical School. Proximity of the two campuses allows for several joint research and research training ventures at Rochester which emphasize opportunities for talented students to develop careers in the biomedical sciences. These ventures include both undergraduate and graduate programs and represent opportunities that simply are not possible at most institutions because of geographical separation of undergraduate and medical school facilities.

Our eleven Ph.D. programs in the biomedical sciences have 302 degree candidates currently in training, 249 of whom are in the School of Medicine and Dentistry and 53 in the College of Arts and Science. Each Ph.D. program provides a Master of Science degree as students fulfill specific curricular and oral examination requirements as they make progress toward the Ph.D. In addition, five terminal Masters programs are offered in the School of Medicine and Dentistry--in Public Health, Dental Research, Microbiology, Industrial Hygiene, and Environmental Science. One hundred twenty eight Masters students are currently enrolled, bringing our total graduate count in the biomedical science programs to 430 students. The graduate enterprise in the biomedical sciences at Rochester is a very significant one in terms of our institutional mission as well as in terms of our contribution to the national pool of well-trained basic research scientists.

I will address those questions you posed for us to consider in the sequence they were presented in your initial correspondence.

1. *Our most significant challenge is maintaining interest in science on the part of talented students as a rewarding career possibility that is worth the personal commitment and effort in time, energy, and ability that is required during the training process*. We are facing a funding crisis in sustaining the fine research enterprise in the natural sciences that our country has established during the past four decades. On the one hand, we hear concern expressed at the national level about nurturing interest in science and mathematics on the part of our young people during elementary, middle school, high school, and undergraduate training. We view dwindling interest in these areas as a matter of great concern that can threaten the future well-being of our society. Programs that foster development of skills for teaching science at these levels and that encourage young people to consider science-related careers are noted as laudable and necessary goals, and resources are being directed to them.

On the other hand, the number of research grants in the biomedical sciences is dwindling. We face a new fiscal year in which the likelihood is very high that the number of new grants and competing renewals that are funded through NIH will probably be no greater than it was five years ago, and perhaps considerably smaller. The scientific community is finding that 15 percent or fewer of approved extramural RO-1 grant proposals are funded, no matter what disciplinary area is considered. Research people often read that 25 to 35 percent of grants are funded, but in fact, the personal experience for those of us in the academic community is that it is unusual to know someone who achieves funding with an NIH Study Section score lower than the top 15 percentile. “Static” in the review system equivalent to one poor or mediocre score among a study section of 15 members can be sufficient to result in an average score that will guarantee lack of funding. First rank scientists who have established research programs that have been productive for many years are uncertain about the next renewal, at best, and at worst are finding that they often have to go back in with multiple revisions to have any chance of continuing their work. Many are not succeeding. Those that do are markedly less productive due to the additional time investment. Set-asides of various kinds have created a situation where not only is the grant number small, but approved budgets routinely

have rescissions of 10 to 20 percent that can mean budgets in the last year of a funded grant that are lower than those awarded for year one of a five year grant. Moreover, new policy prevents funding of a renewed grant at a level more than 10 percent of the amount that was received in the last year of funding. With average rescissions of about 15 percent last year, there is not even a possibility of generating funds on a given grant that can meet inflationary pressure for the past several years. This is true even though inflation has been low. The net result is that research personnel budgets cannot be met, and established talented people in science are not being retained.

The above phenomena are not going unobserved by the generation of young people who might be considering scientific careers or by those would-be scientists currently in training. They understand that basic research requires enormous dedication, long hours, frustration, and sheer hard work. In the past they have shown the personal discipline and dedication necessary to make our biomedical science the envy of the world. Now, however, they see mentors who have been wonderful role models struggling to maintain a career for lack of adequate funding of basic research. They see individuals who have enjoyed science, but who have paid a severe price in terms of having limited personal leisure time because of the demands of their career, suddenly find in mid-life that resources are not there to allow continuation of their chosen career. These young people are asking sobering questions. Among them: Do I really want the time and work sacrifice for so little likelihood of having an opportunity to establish an independent career in basic research?

These young people are beginning to vote with their feet. They leave their first choice of career to pursue alternatives. The message filters back to undergraduates and high school students so that some who might have started on a track toward a professional research-based career never do. The message we have been trying to send with programs intended to attract young people into science is being thwarted by a “reality” message that says the resources are drying up which have been sustaining our National scientific enterprise. This is particularly true for the basic research pursued in academia on which much of the applied research of corporate America depends.

The most significant challenge we face is to be able to provide the resources to sustain science at all levels. In part, these resources need to be directed to sustain established careers in basic science. In part, they need to be directed toward scientists-in-training in the form of more National Research Service Awards with competitive stipend levels. The two are interdependent. One without the other leads either to the raising of false hope for science career aspirations or to a lack of adequate manpower to sustain the enterprise which has driven our world leadership in the biomedical sciences.

2. *Science is under siege*. Mixed messages are rampant. Many in our political leadership and among our citizens applaud the application of science as manifested in new drugs which offer so much hope for solving a wide variety of human health problems. These applications are particularly a result of work in corporate laboratories where the concepts and technology of basic research are brought to fruition. “Technology transfer” to the corporate sector or another arena where it will be “applied” is a current buzzword. Unfortunately, it conveys an idea that only applied research is meritorious and worthy of funding. Simultaneously, it conveys a relatively deep-seated negative set of attitudes about basic research.

During the same time, many of the premier research-based pharmaceutical companies are characterized as the cause of high and escalating health care costs. The attack is causing cutbacks in personnel in precisely the industry that has the most to offer in terms of prospective solutions. This is despite the fact that drug costs are a small percentage of overall health care costs.

We are making two major mistakes in policy regarding research funding:

a. Current policy trends suggest that basic research can be directed so as to optimize cross-over into applications. It cannot, and resources that aim at this impossible goal are not utilized effectively. Funding of either basic research or applied research must be decided first and foremost on the quality of research, where quality is judged by peer review systems. It is a major mistake to believe that anyone possesses the omniscience necessary to determine the direction of the basic research enterprise effectively or the specific ways in which new knowledge should be applied. Attempts at directed basic research will waste money and opportunities.
b. Basic research and applied research should not be funded out of the same pocket. Basic research must be funded in a stable way so as to stop the ongoing growth of applied research at the expense of basic

research. **We are eating our own seed corn!** Applications are the derivatives of the research enterprise, not the enterprise. The use of public funds to try to accelerate the transfer of knowledge from basic to applied areas is largely wasted. Applied scientists have both the incentives and the know-how needed to insure that this transfer is efficient and effective. The economic incentives dictate that this element of our mission will be largely from the private sector. As a nation, we need to decide what portion of our national resources to spend on basic research. Whatever this is, it should be relatively stable such as a fixed percentage of gross national product.

We are sending mixed messages. On the one hand, we say get interested early in science; experience the excitement of a creative career in science; you are the generation to lead future scientific breakthroughs and a higher quality of life for all. On the other hand, sufficient resources are not provided to nurture development through the long interval of training that is necessary; basic science is suspect; the idea is conveyed that we have "created" sufficient basic knowledge--it is time to "transfer" it; we are now even attacking a research-based industry that productively employs scientists in basic and applied endeavors.

As a nation, we are concerned rightfully about many health and environmental problems for which solutions need to be found. However, those solutions depend on an adequate supply of trained scientists some of whom are equipped and willing to pursue basic research and others who find gratification in application of that basic research to specific health problems. The return we will realize from funding additional NRSA opportunities for graduates in training for advanced degrees in science is crucial for meeting our needs as a society. At the moment, additional trainees are particularly important in order to maintain productivity on research grants that are not providing sufficient funds to carry the burden of expense required for staffing our research enterprise. Longer term, we need to be sure that the financial resources are made available to provide opportunities that will allow those trainees to take their places in the research mainstream as post-doctoral fellows and as independent scientists in public and private sectors.

3. *Having participants in our national research enterprise who are from minority groups that are underrepresented in the biomedical sciences in proportion to their number in the general population is a goal of inestimable value to us as a nation*. Unfortunately, it cannot happen until the percentage of total high school graduates who are interested in scientific careers and who are from those underrepresented minority groups is equal to the percentage of those groups in the general population. If we are unwilling to believe this premise we are covertly stating a belief in different capabilities for persons of different ethnic/minority groups. If x is the percentage of underrepresented minorities in the general population, it is unrealistic to earmark funds providing for graduate training of individuals from those underrepresented minorities equal to x percent of training resources when that percentage is not available among college graduates with academic backgrounds appropriate for science careers. We are far from this target at the moment. Without progress on the supply side, NRSA can do no more than make sure that minorities that have demonstrated ability in science are able to continue their careers in science. Additional resources need to be aimed at training elementary, secondary and undergraduate minority students and teachers in science. As these individuals increase in the college graduate pool, there will have to be corresponding growth in NRSA fellowships to allow them access to graduate level training.
4. *Stipends need to be increased from the current level in order to avoid students having a sub-standard of living during the long interval of training required to become competitive in science*. We are asking some of our brightest students to live on an income that is less than a person with a high school education can be expected to make for a period of about five years. Post-doctoral training often occupies another 2-3 years. It is not possible for scientists to make up for the lost income until they are many years into their careers. This is compensated in part by the opportunity to pursue a highly independent research path throughout life. however, if the disparity in lost income becomes too great, this is still another disincentive toward choosing a scientific career path.

STATEMENT BY ALAN G. KRAUT, Ph.D.

My name is Alan Kraut and I am Executive Director of the American Psychological Society (APS).

I am pleased to be able to testify on research training in the behavioral sciences and the National Research Service Awards program (NRSA).

Think New, but Inexpensive Thoughts

I expect the Committee has already reviewed psychology's recommendations from past iterations of this study. Although the American Psychological Society was not in existence then, I was involved in those debates and often wrote the testimony from organized psychology. But I want to caution you against simply resurrecting these past arguments in your current assessment. Times have changed significantly in these last years, both in psychology and in the federal research enterprise generally. A more appropriate strategy for psychology, at least, (and, I would argue, for the Committee) is to throw out all past assumptions and to start fresh in looking at where research training money for psychology and behavioral science can be best spent. For instance, the past controversy over whether postdoctoral training is where significant new money should be spent now seems far removed. Postdoctoral training is more and more the rule in training, and no longer separates, say, the physiological psychologist from the social or developmental psychologist. Instead of these micro discussions, we should be talking about new ideas and mechanisms that could fundamentally influence the direction of the field. One service I think this Committee could provide in these changing times is to be more of a constant monitor of trends in research training, rather than taking the once-every-four-years look that is the case now. Perhaps some small yearly oversight by the Committee can be maintained.

But with all this talk of change, there is one overriding assumption that should underlie all that you consider: there will be little, if any, new money for research or for new researchers for the next several years. Now, and for the foreseeable future, we can expect steady-state funding at best, and more likely, real decreases. I know that we have all heard this same "hard times" argument about funding for the last 10 years or more. But at the end of each of the past 10 fiscal years, NIH and ADAMHA did just fine in their research budgets, particularly compared to other domestic spending. No more.

The Readiness of Behavioral Science

The sad irony in this lack of funding is that it is coming as behavioral science has made major strides both substantively and in its ability to convince federal and Congressional bodies of its importance in addressing national priorities. APS itself is one bit of evidence. As an organization solely representing the science of psychology, we have grown literally from zero to a membership of 15,000 in just four years. And during this same period, the National Science Foundation became convinced that behavioral and related sciences had grown enough to warrant their own administrative structure at the agency; the National Institutes of Health has significantly increased its commitment to behavioral research (and the current NIH reauthorization bill now pending in Congress includes the creation of an NIH-wide Office of Behavioral Research); the National Institute of Mental Health is undertaking an assessment of its behavioral science portfolio that should result in a national plan that in richer days would have increased behavioral research funding in much the same way other NIMH reports have increased the Institute's programs in schizophrenia and neuroscience; and Congress has asked several additional agencies to look toward a behavioral science multiorganizational effort aimed at creating a national behavioral science research agenda, called The Human Capital Initiative, in planning their own behavioral research priorities.

The behavioral sciences have never been more ready to receive the infusion of researchers that NRSA support could bring. In the more biomedical world of NIH, this point often has to be made again and again. The behavioral sciences as well as the biomedical sciences are core NIH disciplines and deserve their fair share of support.

"No Frills" Research Training Needs Emphasis

But the money will not be there. If significant increases are forthcoming, they will likely be tied to science policy areas with major public impact both in terms of public health (like AIDS) and jobs (like the Space Station or the Superconducting Supercollider). It will be up to the leadership of bodies like yours to see

that scientific readiness is also involved in those decisions. Specifically in terms of research training, you need to demand that when NIH officials go to Congress to ask for funds, or when they begin their budget planning within the Executive Branch, they do so with the needs for future researchers at the top of their request list.

As a science lobbyist, I am time and time again faced with asking members of Congress and their staffs for more funding for research training, and time and time again I am faced with hearing the same reply: "How can you ask for more researchers to be trained when even now there is only enough money to fund 25 percent of the proposed research worth doing?" Less funding in the future will only make this argument harder to refute. Yet I go to the heads of the federal research agencies and they always raise the pipeline issue--that there may not be enough good researchers in the next several generations to continue their agency's mission in the same high quality way. But that is not what they tell Congress or OMB. There they talk about the glitzy research being done under the Decade of the Brain plan, or the Human Genome Project, or what breakthroughs there have been in this area or that. Research training, they tell me, is not what Congress or OMB wants to hear about. Don't be surprised, I tell them, if research training is not what they want to fund, either.

Basic Science

Still, perhaps even more so in this age of fiscal austerity, there are opportunities for your Committee to have an important impact on how even relatively little research training money can be productively spent in the next few years. Let me briefly discuss some important issues in psychology's research training.

Among the most pressing problems is the tendency to push too quickly toward applied research in response to budget and political pressures. NSF is in danger of becoming a mission agency. At NIH, the leadership generally takes a narrow view of behavioral science, seeing it in terms of application and intervention without recognition of basic behavioral research. For example, they recognize the need to call on behavioral science in changing attitudes or lifestyles that affect health status directly--how to stop smoking, for instance--while they underemphasize important areas of basic behavioral research on issues like how children develop, how basic processes of learning and thinking take place, what is the nature of the interaction between behavior and biology--areas that need to be investigated before you think about application. The curious part of this is that these same leaders make the assumption that if an illness or disorder has some biological basis, then investing in basic biological research is going to pay off eventually in treatment, prevention, and even cure.

We need to encourage the same assumption on the behavioral side. If there is a behavioral component to a disorder, we need to invest in basic behavioral research if we ultimately hope to intervene effectively. Because schizophrenia appears to have a genetic component, it is natural to assume that research in molecular genetics will inform us about its course. But schizophrenia is also a disorder involving distorted thought, language, and emotions. That means before we can adequately understand those aspects of schizophrenia, we ought to be putting resources into basic behavioral research in cognition, language development, and the regulation of emotions.

Within your mission, this translates into promoting research training in basic behavioral science within NRSA. As research priorities become more applied throughout the federal agencies, it will be particularly important to maintain a quality core of basic research training in behavioral science.

Clinical Science

Now let me argue for a need on the other side--the lack of quality research training in clinical psychology. Clinical psychology training programs are moving toward training more practitioners, with less and less emphasis on research. The reasons are many. They include a changing psychology accreditation system that overemphasizes practice concerns, a marketplace where the salary gap between a research and practice career in clinical psychology is growing wider, a training model that removes a graduate student from a research university to take a year's internship before the Ph.D. is completed, and too little contact with severe mental disorders throughout training. The result is less complicated. With a few exceptions, the next generation of clinical researchers in psychology is nowhere to be found. And this is occurring in the context of psychiatry rediscovering its research base and neuroscience research redefining what we mean by mental disorders.

Let me just touch on two ways I think this can be dealt with. First, clinical training funds (what few there are left) at the new Center for Mental Health Services (formerly part of NIMH) now are geared strictly toward training service providers. A clear mandate that NRSA funds ought to be used to train clinical researchers might provide some counterbalance. Second, clinical psychology graduate students ought not to be the only natural source for clinical researchers. In fact, those who are now making major contributions to clinical research often came from other behavioral science areas. Putting in place incentives for students to get research experience with clinical populations, whether these students are in clinical programs or in programs that are cognitive, social, experimental, measurement, etc., could generate a new core of researchers concerned with clinical issues.

Women in Science

There is one more general research training issue I want to raise. APS has been working for the past few years with NIMH to address that Institute's problem of not attracting younger researchers in the behavioral and social sciences. In 1980, 26 percent of ADAMHA investigators were age 36 or younger; in 1988 that figure dropped to 13 percent. And, at NIMH, 95 percent of this loss was due to fewer grants to young psychologists and social scientists. The good news is that NIMH is about to create a research support mechanism that will be geared to newer investigators in the behavioral sciences. The bad news is that I don't think this addresses the entire problem.

Psychology has been at the forefront of many movements in science. One is the number of women entering a scientific field. But as more women enter the field, what becomes ever more clear is the incompatibility of the traditional new faculty role with the lifestyles of women and young families. Yet, these same women are critically needed in psychological research. I encourage this Committee to consider some new **mechanisms that would create increased postdoctoral opportunities in a way that is more compatible with these lifestyle issues.** We are not talking about women who are any less committed or less serious than their male counterparts. But we are talking about real life issues. Perhaps there could be a program for younger faculty similar to NSF's Women Scholars Program of several years ago. Or perhaps it could be patterned on the Minority Fellowship Program or on the Minority Access to Research Careers that have been effective in encouraging ethnic minorities to enter the research end of psychology, or even on the older National Institute of Education program that was focussed on women and minorities. There may be additional possibilities. My point here is to raise the general issue as one worth considering.

STATEMENT BY TERRY ANN KRULWICH

The opportunities that are at hand for continued and accelerating progress in fundamental and applied biomedical sciences are extraordinary. To optimize the yield from these opportunities, a significant challenge is making careers in biomedical research attractive to and attainable by the most talented and creative American students. Given the manner in which this country achieved greatness in the first place, it is also healthy and appropriate that our training institutions be open to those outstanding foreign students who genuinely want to pursue research careers and may ultimately be eligible to do so in this country. Such training activities in American universities should not be seen as a disclaimer vis a vis training of domestic students. During this particular year, the experience at my own institution suggests something of an upturn in the highly qualified students from undergraduate schools in the United States who are embarking on Ph.D. training in biomedical sciences, and who have impressive prior research exposure. In order to further expand and nurture this group, early science education and the image of the scientist have to be improved; the availability of traineeships/ fellowships must be maintained and, if possible, expanded; a constructive attitude towards science as a career must be developed; a strong portfolio of diverse career options (including academic and industrial research, technology, teaching, and various ratios thereof) should be developed and disseminated to undergraduates and graduate students; and, of course, the health of the research funding situation and the perception thereof is essential. You might consider allowing payback credit (if payback is retained) for teaching science to undergraduates (in small schools with little or no research) or advanced high school students or science-oriented minority students in special enrichment programs. This will dignify such a professional commitment and

acknowledge its relationship to the health of the enterprise. Programs that are targeted towards minority groups are essential, and the earlier they start and the more sustained they are, the better--with the caveat that no such program should be mounted without established criteria whereby its success can and will be monitored.

And the NRSA awards? First, do no harm. Do not further reduce the source of the very best in training, and encourage the special advantages of such awards. These include programmatic features (especially for predoctoral trainees) that foster rigorous theoretical training in broadly based fields. Trainees need such exposure so that while they conduct their own research in a well-defined problem area, they are not trapped by a narrow perspective or limited capability for adapting to new trends in a later career. The periodic establishment of new training grants, in cross-disciplinary interfaces, is highly desirable. NRSA programs also provide freedom to investigate a number of different training settings before choosing a laboratory whose style and focus are syntonic. And the hallmark of the institutions that generally compete well for institutional NRSA awards, or individuals with their own fellowships, is the presence of a peer group and training faculty that is optimally equipped to create an environment, transmit the values, and carry out the explicit training.

In connection with improvements that might be made, I would like to focus on just a few areas. The first is in the area of retention of minority students. During the past decade there has been an emerging emphasis on the recruitment of minority students to training programs in biomedical sciences and even the development of new NRSA awards for such students. It is important that the success of the programs in retaining students be monitored, and that factors in successful retention and longer term success of the trainees begin to be identified. Innovative approaches to retention should be fostered, e.g., the cooperation between different institutions in metropolitan areas to help provide a critical mass of minority students for programs that will foster their collective and individual morale and progress, or more formalized participation of research faculty from research-intensive institutions as mentors to young faculty/students at smaller, more teaching-oriented institutions with funded minority programs.

The second area that I would like to highlight is the problem of whether we are providing the means whereby our NRSA trainees, who encompass many of the most talented future biomedical scientists, can go on to work in new and creative research endeavors. I feel strongly that the opportunities for success in many rapidly moving fields, together with the constrained funding times, conspire to make new investigators conservative in their first (often FIRST) grant proposals and project plans. That is, increasingly newly hatched junior faculty propose a direct take-off from prior work which offers only minimal differentiation from the parent postdoc lab. It is too risky to propose something more individual and novel. This hurts the whole enterprise.

I would like you to consider a program whereby for all postdoctoral NRSAs, a period (launch period?) of ? (6 months? 8 months?) at the end of the award be set aside for the trainee to develop his/her own initiative, to start to gather those crucial initial data. Preceptors on such awards will have to pledge their willingness in advance. The specific plan will need to be developed while the trainee is engaged in the training project and then filed (3 months?) before the launch period. Some supply funds should be set aside for support of the work to be conducted. That work should be distinct from the work of the training lab in some fundamental way, should be the intellectual property of the trainee (no ultimate coauthorship by postdoc mentor, etc.). The period should be used to garner initial data and feasibility analyses for an original idea. The preceptor gives up lab space and some amount of supplies in return for all the prior support of a postdoc in the lab. For women or men, who are spending time “at home” with a baby, maybe special “launch periods” in an earlier postdoc lab or some nearby lab could be fostered through existing NRSAs or extensions thereof; these could allow a new parent some support to develop an independent project area during a partial “down time.”

Finally, there should be even further encouragement of the individual mentors of NRSA trainees to act as mentors for more than just the project. A global program statement about training in responsible conduct in science is insufficient. Each mentor (they are usually the best scientists on campus) must be willing not only to ask trainees to help review articles (many, if not most, do) but must be willing to discuss the conflict of interest and ethical problems involved therein and model appropriate behavior. Attempts by Program Directors to engage these very stellar faculty members are often met with the “it’s the local girl-scout cookie sale time” reaction. Trainees,

however, are often less cynical, and hunger for guidance on how to write a proposal; when to send a probe; if I send a probe, should my name go on the paper?; etc. Collectively the mentors and trainees need to explore the often challenging issues that increasingly surround the practice of science, thereby affirming the principle that in the practice as in the substance of science, open and thorough exploration of a problem is the productive approach.

STATEMENT BY VINCE J. LICATA, Ph.D.

Along with this committee, I share an avid interest in the direction of the biosciences in this country--both in regard to how the scientific community itself is defining its needs and goals, and in the way the scientific community interfaces with the governmental and industrial institutions which "pay for" the sciences. I'll preface my remarks by saying that when I speak of a "scientist," I am generally referring to basic researchers in the academic setting. I define basic research as a knowledge driven, curiosity driven, unrestricted exploration of the structure and function of the universe, which is never initially directed toward any specific applied use.

As well as presently being an NRSA/NIH postdoctoral fellow, I was supported by an NRSA/NIH training grant during part of my graduate work. When speaking about the NRSA program I will be predominantly speaking about the individual NRSAs. This is because while a graduate student on an NRSA/NIH training grant, at least at The Johns Hopkins University, one knows little more about one's funding situation than the fact that one is "on a training grant. " Although I was funded by it for three years as a graduate student, I did not really know what the NRSA program was until I applied for a fellowship.

Here are my responses to the questions in your letter of March 2, 1993:

1. *The most significant challenge we face today in the United States for maintaining an adequate supply of qualified scientists to sustain and advance health research is making the profession of being a scientist one of the most attractive career choices for intelligent and motivated people*. Obviously the higher the caliber of people becoming scientists, the higher the caliber of the resulting science. Roadblocks to achieving this goal lie both at the level of the scientists themselves and at the level of the general public.

As regards the scientists themselves: the most common opinion that I encounter is that scientists feel they are overworked and underpaid--especially during the "early part" of a scientific career. If one uses the standards commonly used to evaluate one's "career success," this is undoubtedly a true statement. When scientists compare their salary to those of lawyers or certified public accountants, we seem rather undervalued. Part of the problem is, however, the incongruity of the comparison. When evaluating their career "worth," scientists often overlook the facts that they get to set their own hours, choose what they work on, take sabbaticals, become tenured. In short, scientists themselves need a better understanding of their profession--of the fact that they have traded the usual (monetary) measures of "success" for success of a different kind. This may seem a blatantly obvious point, but I have so often encountered the "answer" that we must pay scientists more (which is, of course, also partly true) that I think it worth stressing (to scientists) that society does pay them "more," just not in money.

Another part of the problem lies at the level of public opinion. Current public opinion toward scientists is horrifyingly low. There is constant press coverage of the apparently massive amount of fraud in the biosciences. All scientists become implicated by this. Scientists are regarded as gold-bricking, elitist snobs, who sit in their ivory towers doing nothing all day because they have tenure and can never be fired--and now it's been discovered that what little work they actually do is probably faked (so why pay them more?). Such a climate certainly deters good people from entering the field. Such ridiculous perceptions must be vigorously countered by public affairs divisions of universities and national scientific organizations--more vigorously than is being done now. Scientists must begin speaking to the people. Perhaps all NRSA grant recipients should be encouraged to perform some form of public education as part of their training, such as writing a newspaper or magazine article, or speaking to a community service group, etc. Educating the public by educating those presently in school is, of course, a primary answer, and I believe that there has been significant progress in organizing for that goal on the part of several national scientific organizations. What I believe is being somewhat overlooked, however, is the need to educate people who are no longer "in school."

Parents will not push their children to learn science if they themselves cannot see the value of it. Why is the New York Times one of the only newspapers in the country to have a science section? Why is "Mr. Wizard" (or an equivalent) no longer on television? The power of such a simple concept as the Mr. Wizard show in influencing the career choices of the population should not be underestimated. TV shows like NOVA and Newton's Apple, etc., are very good, but they do not create the image of a scientist as a role model, a person, as someone to become.

Unfortunately, it is very difficult to ask scientists to re-evaluate their societal worth and to spend more time speaking to the public at a time when they must spend nearly every waking moment writing grant applications that probably will not get funded. It is difficult to ask graduate students and postdocs to address these issues when they are in constant fear as to both their future job prospects and research funding in the basic sciences. This is not an issue that you have asked for an opinion on, but it is an issue that must be addressed before we can expect to entice good people into science. The easy answer is: give more money to NIH, NSF, USDA, NASA, etc., for basic research. The more realistic answer, I believe, is to define basic research as a necessary institution in itself, to decide how much basic research we (as a planet) need to be doing, employ enough basic researchers (not too many, not too few--mostly at universities), and then guarantee them the funds to do their work, i.e., to make basic research a "national goal. " The only limitation on basic research should be the inherent ability of the scientist.

2. *In my opinion, expansion would be the biggest improvement in the NRSA program in the coming years.* The figures I have indicate that there are a total of about 2200 individual NRSAs for all of NIH. This attaches a nice prestige to getting an NRSA fellowship, but if the goal of the program is "to assure a continuing supply of skilled investigators in the biomedical and behavioral sciences," then the program must be made less of an honor and more of a general career route. This of course means "more money," which is always the solution which is easiest to propose and the hardest to enact. There are, of course, a much larger number of institutional NRSAs.

Personally, I have had very few complaints regarding my own NRSA. The problems that I do see are mainly administrative and seem to be "par for the course" for NIH funding. The amount of paperwork involved in applying for the NRSA fellowship far exceeds that required for any other postdoctoral fellowship. If other awarding institutions make decisions based on a more streamlined application process, then it seems that NIH could. Even the continuation applications are longer than the initial applications for most other fellowships.

A possible improvement to the program that would not involve a lot of extra money is to have yearly national meetings of individual NRSA recipients, divided by research areas, and to have NRSA recipients present their work to each other and to the study section members and NIH officials who coordinate the program. Such meetings might be held a day before or after large national meetings such as ASBMB, ACS, or FASEB, in order to cut costs and save time. Not only would this serve to initiate possible future collaborative relationships, but would allow one on one communication between NRSA grant givers and recipients. The NRSA recipients would get to present their research results to a highly receptive audience while NRSA and NRC officials would gain information to help them evaluate the NRSA program at very close range.

3. *The problem in recruiting women and ("underrepresented" or non-Asian) minorities into scientific careers is a signature symptom of the deeply ingrained white male dominance of the scientific profession.* It is no secret that the civilized world is male dominated, but the dominance of the white male in science is one of the most explicit cases of this world order. Unfortunately, changes in the NRSA program will only have limited impact in this area. This is because the majority of discrimination relative to the scientific professions happens at levels higher than the postdoctoral level (as well as at levels much lower--at the preschool level, etc.). I believe, however, that any impact is good, and can always be the start of, or a part of a larger change toward gender and racial equity in the sciences. Even though the application process for individual NRSA is presently theoretically "color-blind" and "gender-blind, " the entrenched white male approach to research serves to make applications by white males automatically more attractive. I contend that, without any overt intent to discriminate, proposals by white males merely seem to be "more on track" and are ranked higher by study sections because of the strong

tradition of seeing the white male approach to science as being equivalent to an objective approach to science.

I would propose that the percentages of NRSAs awarded to men and women should be in exact accord with the percentages of men and women applying during each application cycle--no exceptions. With minorities the question is more difficult because during any one application cycle there may be only one or two applicants of a certain racial minority applying for NRSA support. In this case I would propose that a universal (but relatively low) cutoff level be decided upon (i.e., a cutoff that eliminates only "really bad" applications), and then that all applications above that cutoff level be awarded, again, in exact proportion to the racial distribution of the applicants. The cutoff system would be for the prevention of funding "bad applications" merely to satisfy the racial distribution directive. Since the ratio of men to women applying should generally be somewhat closer to even, the use of the cutoff system in the case of gender balancing would not be justified. Quota-like proposals such as this tend to lead to difficult questions, and often seem to discriminate against white males, but since the primary purpose of the NRSA program is "training" rather than "supporting the 'absolute best' research," it should, indeed must, be utilized as a step toward gender and racial equality in the sciences.

4. *As I stated in my opening remarks, I have little familiarity with the operational details of NRSA training grants*. I would assume that research training environments must prove themselves to be of at least a certain level of quality in order to obtain NRSA support. I know that there exists a site visit program for evaluating potential training centers and I believe this should continue--it certainly is one of the fastest and most accurate ways of evaluating a training center/graduate program. In the same way that the American Chemical Society requires certain facilities and curricula for a program to be "ACS certified," perhaps the NRSA program should establish a minimal "NRSA certification" in order to qualify for NRSA support. Such a certification requirement should be kept minimal, however, as too much standardization of programs would not be beneficial since much of the strength of science is in diversity of approach.

In reply to your last (un-numbered) question: How do, and how should the current changes occurring in employment opportunities in the biosciences reflect on the training of bioscientists? Answer: not at all. In my opinion, scientists should be trained first and foremost as basic researchers. To train a scientist in a "targeted" way, with an eye toward a specific (read: applied) research setting, is to severely limit that scientist's potential. The applied bioscientific needs of this country and the world are rapidly increasing. This is wonderful, and it means there will be numerous job opportunities for bioscientists in the future. Well trained scientists will be able to change with the biotechnology industry, if they have been trained in the fundamentals and have been taught how to formulate a question and approach a problem. They will be able to handle any new project that comes their way as we move into what surely will be a biosciences era. Although there will also be jobs aplenty for people trained in specialized biotechnological processes, the "scientist" of the future should continue to be trained primarily in methods of thinking and in understanding of the basic forces and structures of life. The NRSA training program should not be focused toward one or several target areas, but continue to be based solely in terms of scientific merit and broad based training potential.

STATEMENT BY DANIEL LINZER, Ph.D.

I am an associate professor in the College of Arts and Sciences at Northwestern University, and I am also the Director of our NRSA Training Program in the Cellular and Molecular Basis of Disease. In preparing this statement, I have attempted to integrate the ideas and concerns of my colleagues at Northwestern who are past or present directors of NRSA training programs. Even with this advice, the task of making specific recommendations for changes in the NRSA program is challenging, given the breadth of these programs and the divergent points of view about predoctoral and postdoctoral training held even within this group of faculty scientists at a single institution.

The most optimistic point of view that I heard is that the current numbers of predoctoral and postdoctoral trainees should and will increase, and that the long term prospects for professional advancement of these trainees to permanent positions as practicing scientists are good, or at least as good as anytime in the past. A corollary to this viewpoint is that sufficient funds will be available for the training of these students and for their

research programs as they graduate into independent positions. A further prediction is that biotechnology companies will absorb significant numbers of Ph.D.-level life scientists as that industry continues to expand.

Although all of us feel that training of predoctoral and postdoctoral students in the life sciences is a national priority and a sound investment for the future of this country, most of my colleagues believe that the optimistic point of view is not realistic for the short term. Given the present economic conditions, we are unlikely to see the national budget for life science research and training keep pace with an expanding trainee population. Furthermore, the demands on this budget, by large scale directed research in a few areas such as the human genome project and AIDS, and by ever larger numbers of research grant proposals submitted for ever greater direct costs, suggest that it may prove difficult to maintain support for even the current number of trainees in NRSA grant and fellowship programs. Redirecting biomedical research dollars towards training is not a solution, though, since a major disincentive for predoctoral and postdoctoral trainees to continue in research today is the difficulty they anticipate in obtaining sufficient funding to support their research efforts.

As to the availability of positions awaiting these trainees, it does seem likely that biomedical research and biotechnology will continue to be areas of economic growth in the future. However, applications for each academic position today generally number in the hundreds, suggesting that there are many more qualified candidates than faculty positions. In the immediate years ahead, the expansion of research and development divisions of pharmaceutical and established biotechnology companies may also be limited due to the slow economy, the recent federal emphasis on reducing pharmaceutical prices, and the adoption of a new national health plan. Also, many of the personnel needs in this industry may be met by hiring mid-level life scientists (masters and bachelors degree recipients) rather than Ph.D.s. Thus, a significant problem will be to train the number of life scientists required to meet this country’s long term needs, while at the same time addressing the short term funding restraints and outlook for jobs.

Changes designed to deal with this problem must also be compatible with the major objectives of NRSA training programs. The first objective is to produce Ph.D. scientists capable and determined to become independent investigators in academia, industry, research institutes, or government research laboratories. To accomplish this goal, it is necessary to attract the brightest students to the sciences. For those undergraduates who are interested in science, most go on to medical or other professional schools, rather than graduate school. Several factors may contribute to this decision, including the fixed length of the professional training process, the availability of jobs after completion of the training period, the relatively high salary, the long term prospects for success, and the perception that graduates of medical, law, and business schools have an elevated social status.

Graduate school in the sciences offers a stark contrast for each of these factors: the training period (predoctoral and postdoctoral) is of indefinite length, but on average 5-6 years for a Ph.D. and 3-4 years for postdoctoral studies; the job market, especially at academic institutions, is tight; postdoctoral stipends are low, as are starting salaries for independent scientists; those fortunate enough to obtain an independent position find it increasingly difficult to compete for funding and to maintain a long term approach to research; and scientists are routinely portrayed to the public as uncaring, unethical, and out-of-touch. To encourage the brightest students to become scientists, all of these factors must be addressed.

One possibility for attacking a few of these problems would be to decrease the number of training positions and increase the stipend level. For example, raising postdoctoral stipends to an attractive level may be an inducement for students to pursue science as a career. NRSA stipends are so low that technicians with a bachelors degree who are working for 1-2 years before entering medical school often have starting salaries higher than for postdoctoral fellows. If a constant amount of funding is available for postdoctoral support, raising stipends would decrease the number of funded positions. In the short term, this would be expected to decrease the number of postdoctoral fellows, which may ease their subsequent job search. Increased competition for hiring postdoctoral fellows might then contribute to a decrease in the average length of the postdoctoral training period.

Consideration should also be given to revising the funding for predoctoral trainees by having the federal government pay the real costs for stipend and tuitionagain, causing a decrease in the total number of positions that could be supported. Alternatively, NRSA funds could continue to contribute a share of these

costs, if the policy that prevents supplementing NRSA trainee support with funds from a federal grant is changed. This policy seems outdated and unfair since NRSA funds no longer approach the normal level of graduate student support.

A second goal of NRSA programs is to attract minority students and women to careers in the life sciences. Two issues affect the appointment of minority students to NRSA training programs. First, support for these students can usually be obtained from other sources, providing a disincentive to fill the limited number of NRSA slots with minority appointments. Second, efforts to recruit minority students frequently result in admitting students with relatively weak quantitative records (GPA and GRE scores). Setting aside a fixed percentage of training funds for minority students would encourage appointment to NRSA programs and would enable minority students to be evaluated as a group.

Recruitment of women into training programs is not a problem; instead the problem is in the number of women who successfully graduate into independent positions in science and who are promoted into the higher ranks. One contributing factor appears to be a relative scarcity of appropriate role models for women (and for minorities). Furthermore, women (and minorities) may not always receive the same amount of time, encouragement, and consideration for advancement from their mentors as do other trainees. The training environment might be improved if NRSA programs were charged with sponsoring seminars for women and minority scientists, and if, in addition to requiring discussions on science ethics, NRSA programs also included discussions with both faculty and students on the apprenticeship system of research training and the responsibilities of mentors to all trainees.

One of the principal effects of NRSA funding is to encourage universities to commit additional resources to life sciences programs. This effect is achieved by evaluating the degree of university commitment to the life sciences as part of the application process. In addition, these awards represent recognition of programs of excellence, and are, therefore, of great value for recruitment of predoctoral and postdoctoral fellows to institutions. Since NRSA funding can influence university spending priorities, it is important that these programs coordinate an effective and fair set of cost-sharing guidelines. A major challenge will be for federal funding to assist universities in maintaining effective research and training environments at a time when life sciences research grows increasingly complex and costly, and investigator initiated research grants become more difficult to obtain.

To simplify the funding process, the current policy of dividing faculty and students into many separate but overlapping training programs should also be reconsidered. Historically, training programs were developed for distinct areas in the life sciences, but the boundaries between these areas have almost completely disappeared. An alternative approach is to have a single training program (or at least fewer programs) in the life sciences, by combining training funds from each institute at the NIH. The level of NRSA support could then be based on the recent performance of each institution, taking into consideration the amount of peer-reviewed grant support, the records of the graduate and postdoctoral trainees, and the performance of these trainees after leaving the institution.

A potential problem with this approach is that training funds may be even more unevenly distributed than they are today. Since support for predoctoral and postdoctoral training is crucial in attracting the best students and faculty, the success of an institution may be directly related to the amount of NRSA funding it receives. Furthermore, successful academic institutions strengthen their communities and provide valuable resources of graduates, technologies and ideas, and consultants and collaborators for local industry. It therefore seems imperative that federal funding encourage trainees to attend institutions throughout the country. One mechanism for balancing the geographical distribution of NRSA funds is to adopt criteria that increase in difficulty for the awarding of each successive training slot to an institution.

Finally, the only way to encourage the best students to embark on careers in the life sciences is to improve the long term outlook for basic biomedical research. No matter how enticing the training program, if predoctoral and postdoctoral students find that their faculty advisers spend much of their time in anxious, and often fruitless, quests for research support, we will be sending a discouraging message that will be difficult to overcome. Although NRSA funding cannot address this issue directly, it can serve to promote and encourage the support of high quality research environments at our training institutions.

STATEMENT BY CAREY NIEN-KAI LUMENG

My name is Carey Lumeng and I am a first year fellow in the Medical Scientist Training Program at the University of Michigan.

Today I would like to focus on the needs of the young student. Having recently grappled with choosing a career, I feel that I have a good perspective from which I can identify the needs of young science students. In my presentation I would like to focus on the forces that persuade and dissuade students from entering research science.

Let me first tell you a little about myself. I am a Chinese American who was born just down the way at Walter Reed Army Hospital, but I was raised in Indianapolis, Indiana. My mother is a musician and my father is a physician and researcher at Indiana University. I attended public schools through 8th grade when I enrolled in a private high school. I continued on to Princeton University where I majored in Molecular Biology and graduated last year. I am just about to complete my first year of medical school training at Michigan and have not as of yet decided on an area of concentration for my Ph.D.

As I struggled with what I was going to do with my life after college, I reflected a lot on the influences that caused me to choose a biomedical research career. One element I identified is that my excitement about science started early. I feel most people in this room can relate to this. If the NRSA program is interested in maintaining a steady supply of research scientists, it must have an interest in establishing the high level of excitement about science in grade school and middle school aged children which will lay the foundation for future growth. In short, science education must improve.

I recently took part in a program sponsored by the American Medical Student Association at the University of Michigan that presented a course to 7th and 8th graders on the dangers of substance abuse. The school we visited was in a poor, blue-collar suburb of Detroit where very few students were expected to make it to college. For one session, we presented actual body organs for the children to see, touch, and learn about. I can only begin to explain to you the interest that this exercise raised in the children. I had been used to fighting for their attention, but I was stunned when they all listened attentively and quietly to me talk about the heart. This was also the first and only class where the students did not run for the door when the bell rang. If you've ever worked with 8th graders, you know that this is quite an accomplishment.

This experience showed me that these children, who come from a background very different than mine, could experience the same fascination with science I had when I was their age. These kids have the potential to become scientists, but without the correct nurturing, they will never come close to this goal.

If the NRC is concerned about the future supply of scientists, then it is these children and children like them all over the country that should be given our attention and concern. I realize that setting the NRSA program on the task of revamping American science education is probably out of the scope of the program, but I feel that steps in this general direction can and should be taken. The involvement of groups such as the National Research Council in precollege science education can come in the form of awards to science teachers and to programs that are using innovative teaching techniques. Grants to schools in underprivileged areas that desperately need equipment, teachers, and other resources can make a difference in students' lives. Communication and coordination between the NRC and the Department of Education may serve as a link that can feed ideas and personnel to science departments in schools. These ideas are very general but I feel that such measures can help reach the goal of improving the quality of research science. At the very least it will help create a public that can better appreciate and understand scientific discoveries.

From the youngest minds. I now turn to the young adults in high school and college that are beginning the serious search for what the heck they are going to do with their lives. On April 22 of this year, the New York Times printed the words of 16 year-old Emma Kramer-Wheeler from Brooklyn, who best sums up what I feel these students need. She said, "Role models really help. I think that might be the most important thing. If you see somebody who you can relate to, who has gotten somewhere, you know you can get somewhere." I was fortunate enough to have a means through which I could picture myself in science--my father. For many other students, lack of contact with role models in science hampers their development. Science interest alone can only get a student so far. A student must also be able to see him or herself in the career to have a grasp on what the future might hold for them.

I feel that the NRSA program could be used to help foster a network of dialogue and contact between research scientists and students at all levels. Often something as simple as an hour's visit can be enough to help a student realize that someone similar to them is making a career out of science. Outreach programs can be established to send graduate students and faculty to speak at schools, bring interested students to research facilities, and provide opportunities for high school students to work in laboratories where they can interact with career scientists. Such programs focusing on minorities and women can make great strides in influencing more of them to pursue science, as role models for them are often hard to find.

Moving down the educational path, what are the needs for the college student who wants to make a career in science? As many students weigh the option of entering research science, a major factor in their decision is often the opportunities they have been given to explore first hand what research projects entail. That was how I learned that research was for me, but I was fortunate enough to attend a school that required all students to do independent research. For many students at other colleges and universities, however, the opportunities to "try out" research are much harder to come by. I feel that there is much the NRSA can do to give more students a chance.

Each Spring thousands of college students search for something to do for the summer. I was once one of these students, and was amazed at how hard it was to get the information on available programs. It took me months of searching on the lab hallways and collecting those little cards off of posters before I could get enough leads. Something as simple as publishing a comprehensive guide of information on summer research programs will increase the number of students interested in them and make the search much easier for students. More importantly, there is always a need for more funding for summer and year-long research experiences for undergraduates. Areas and schools lacking the research support of larger Institutions should be targeted. Expanding these programs can immensely improve the quality and quantity of the students in research.

I am currently taking classes in the University of Michigan Medical School. Many of my classmates have strong research backgrounds and I have asked them why they chose medical school instead of research. Beyond the normal "blah blah blah" about their dreams about healing people, the most frequent response I get is that the current atmosphere of competition for funding and positions turned them away from research. Many of my classmates state that they are definitely planning on being involved in research, but only after they have completed medical school. This shows that students' training strategies are definitely changing in response to employment opportunities.

Also reflective of this is the choice that hundreds of students have made, including myself, to enter combined M.D./Ph.D. training programs. I think that a factor in every student's decision to undergo such extensive training is the opportunities for employment that can open up with a combined degree. For students that have already established firmly in their minds that they want a career in biomedical research, an M.D./Ph.D. program provides the best way for them to improve their chances of remaining employed as a researcher.

I encourage you to continue support for the Medical Scientist Training Program (MSTP). The programs provide an invaluable source of support and guidance on an academic level and beyond. The MSTP is a program that is much more than just a source of funding. MSTP students are, in general, weird people in that we aren't truly medical students, nor are we graduate students, despite our involvement in both areas. My experience at Michigan has shown me that the program is a focal point for students of a common interest that works for the benefit of all.

STATEMENT BY THOMAS E. MALONE

On behalf of the Association of American Medical Colleges (AAMC), I am pleased to be with you today to discuss research training and the National Research Service Award program. With some 62 percent of all National Research Service Award funds conferred on academic medical centers or their trainees, issues of research training are of great interest to the 126 medical schools, more than 400 teaching hospitals, and 89 professional societies included in the membership of the AAMC.

The task facing this committee--to advise the National Institutes of Health and the Congress on the future direction of the NRSA program--is a formidable one, and made all the more so by the existence of a

multitude of formal and informal pathways to training in the biomedical and behavioral sciences. In crafting your recommendations for the National Research Service Awards, I urge the committee to thoroughly review the range and quality of research training in the United States today, and consider its implications for the future of the scientific enterprise.

As we approach the apogee of a new era of discovery and technology in biology, we face the perennial challenge of stimulating young minds to pursue the range of opportunities, from undifferentiated research to the translation of discoveries into products that will meet society's needs. The quality and number of NRSA trainees should reflect a balance of these imperatives.

Challenges to Maintaining an Adequate Supply of Qualified Scientists

Our nation's ability to maintain an adequate supply of qualified scientists has been sorely challenged in recent years by a lack of community consensus on just what constitutes an "adequate supply." Only a few years ago, for example, it was widely held that a shortage of scientists was imminent. Today--alarmed, perhaps, by failing success rates--some are convinced that the number of investigators is too great. When opinions can shift so quickly and so completely, it is difficult to believe they are grounded in fact.

While employment forecasting is a notoriously difficult and inexact science, your committee's efforts can do much to clear the dissension that has marked recent discussions of research training. I hope you will not only be scrupulously realistic in your assumptions, but forthright in your report about the outlook for federal funding of research and the probable differences in employment prospects for the academic and industrial sectors. If you do so, and communicate your recommendations broadly, you will do much to help guide scientists, educators, and policymakers as well as to prepare students for what they can expect as they enter the job market.

Ultimately, we would like gifted young people to be attracted to research not only for its excitement and challenges, but also because salary levels and the numbers of job openings convince them that their chosen field will offer ample opportunity to build a stable and rewarding career.

Improvements to the NRSA program

While long-range prospects supply the most compelling reasons for pursuing a research career, more immediate incentives, such as stipends, play an indisputable role. With that in mind, it is disturbing to note that stipend levels for trainees in the NRSA program have remained unchanged since 1991. Not only should stipend levels be increased to reflect inflationary changes since then, but the training budget should be sufficient to allow cost-of-living adjustments to be made annually, and computed into each training grant's continuation base.

As young physicians are likely to be more sensitive to the financial disincentives of pursuing a research career than their peers in other fields of science, their situation deserves special attention. Even when training stipends were increased in 1991, they still fell well short of housestaff salaries for those with comparable years of experience. For highly-indebted young physicians, furthermore, the impediments to a research career are greatly compounded. Additional loan repayment programs, like those initiated by the National Institute of Allergy and Infectious Disease for intramural AIDS researchers, would do much to encourage young physicians to pursue research careers. At the very least, physician scientists participating in NRSA programs should be granted loan deferments during research training.

With respect to basic science training, we would draw your attention to a number of questions posed by previous committees, and made more important by the constrained financial circumstances we face today: (a) whether the current supply of new Ph.D.s and postdoctoral fellows is sufficient to meet academic and industrial needs once attrition (including the departure of foreign nationals) is considered, and (b) the extent to which the committee should consider other sources of training, such as private funds, institutional and state scholarships, research-grant-supported training, and other federal programs. We would also hope that the committee will continue its efforts to address the difficult problem of tracking the careers of trainees as they enter academia, industry, and other arenas.

The clinical sciences have benefitted in recent decades, from an increasing number of Ph.D.s joining the clinical departments of medical schools and conducting clinical research. Data from the 1975 NIH

Manpower Survey indicated that some 20 percent of NIH "clinical science" grantees were Ph.D.s; by 1990, more than 45 percent of the principal investigators for NIH-funded research grants involving human subjects were Ph.D.s. While Ph.D.s have played an invaluable role in the clinical sciences, it is one that is circumscribed by the extent to which they are able to interact with patients. Without a sufficient cadre of physician clinical investigators, the degree to which we can take advantage of the strides in understanding basic human physiology and pathophysiology is markedly limited.

With tuition and stipend payments assured throughout their schooling, students in the Medical Scientist Training Program are clearly more insulated from financial pressures than other trainees. By graduation, their educational debt averages $23,000, while that of the typical graduating M.D. is $56,000, more than twice as much. By all indications to date, the MSTP program has been remarkably successful at cultivating committed physician scientists. A 1992 study of graduates of the Johns Hopkins University's M.D./Ph.D. program found that all of those who had completed their training were actively involved in research: 81 percent in academia, 14 percent at research institutes, and 5 percent in the biotechnology industry.

Some have expressed concern, however, that the program could do more to encourage its trainees to pursue problems in human disease--a research area for which they should be uniquely qualified, but, by some indications, are disinclined to pursue. While the goal of the MSTP program is to train both basic and clinical researchers, Washington University's Carl Frieden, Ph.D., and Barbara Fox reported in 1991 that 83 percent of their MSTP graduates were engaged in full-time basic research. Similarly, in a 1990 analysis of the research publications of a sample of MSTP graduates, Edward Ahrens, M.D. found that 75 percent of their work focused on nonclinical research.

In making its recommendations, this committee has traditionally counted MSTP trainees in the clinical science category. Yet findings such as those of Frieden, Fox, and Ahrens suggest that at least some portion of that group should be considered basic science trainees. In addition, should further study confirm that MSTP graduates gravitate toward narrow areas of research, broader training would seem to be in order.

Enhancing the Effectiveness of the NRSA Program in Recruiting Women and Minorities

Although women today are much more likely to pursue careers in the biomedical sciences than in decades past, the NRSA program can encourage even greater participation by endowing its programs with the maximum flexibility possible and developing formal policies for family leave and part-time training. While I understand that such policies are under development at NIH, I would urge their swift adoption. After all, it was in 1977 that this committee first discussed the importance of flexible training opportunities for women. Such policies, moreover, are likely to improve the training environment for all trainees.

Increasing the role of minorities in science, however, may require a more activist approach. While some training programs admittedly could do a better job of recruitment, and NIH might do more to highlight and encourage strong recruiting strategies, the fact that recruitment at the pre- and postdoctoral levels has had only minor effects over the last decade suggests that the key to fostering minority scientists lies in the college and secondary school years. To the extent it is able, the NRSA program should broaden its focus to encourage greater participation in programs such as the MARC undergraduate awards.

Implications of Current Employment Opportunities for the NRSA Program

The great strides that have been made in basic research over the last decade, as well as more recent progress toward health care reform, would seem to call for an emphasis in NRSA training programs on interdisciplinary approaches that pair the biomedical sciences with chemistry, engineering, and computer science, as well as patient-oriented clinical research, clinical epidemiology, biostatistics, outcomes research, and health services research. With regard to the latter, I am pleased to note that you and your colleagues plan to return to the approach of previous committees and evaluate personnel needs in the field of health services research as well as the biomedical and behavioral sciences.

It is with less optimism that I note that the fields of epidemiology, biostatistics, and the general arenas of

the clinical sciences and health services research have been repeatedly mentioned by previous committees as deserving special attention. These trends seem to indicate chronic shortages, and deserve more attention than they have received to date.

STATEMENT BY BRYAN E. MARSHALL, M.D.

For approximately 20 years I have been involved in the research training of anesthesiologists at the University of Pennsylvania. A major part of this effort has been as Principal Investigator of a National Institute of General Medical Sciences Grant for Training in Anesthesia Research. The purpose of this grant is to train physician anesthesiologists to become competent researchers by providing 2 years of full time research fellowship after completion of residency and prior to joining a faculty. Our use of this grant has evolved considerably. At its inception 15 years ago, we recruited informally and developed a trainees' program in our laboratories. Now our advertising, recruitment, and selection process begins 4 or more years before the training starts. Training is rarely conducted in our own laboratories, and the preliminary consideration of course work and practical training is established well before the fellowship begins. The aim is to have the trainee return to the Department to join already established research teams but now bringing a new area of expertise and collaboration to that team.

My perspective is therefore drawn from this experience, and is based on research aimed ultimately at clinical problems concerning anesthesiology, intensive care, and pain management. Approximately 80 percent of graduates of this research training program are now on the faculty of major academic institutions, 10 percent are in hospitals affiliated with medical schools and only 10 percent are in private practice. Despite this reasonably successful outcome, I am concerned that many more clinical scientists "slip through our hands."The thesis I should like to advance here is that clinical scientists are in short supply, and that the cure for that situation may lie not so much in a broader recruitment effort, but in a serious effort to reduce wastage of potential candidates.

Undoubtedly, the pressures on a clinician scientist are great, and it is easy to dismiss the problem of their short supply as there being simply too few such ambitious and multi-talented individuals presenting as potential trainees. Furthermore, although improvements in our educational system would undoubtedly provide a larger pool of candidates, that does not appear to be the major problem except in certain areas. Instead, it is one of wastage of the available candidates. This waste is encountered in three forms.

For the research fields of my clinical horizons, the Postdoctoral Research Training Grant is the critical program. The most effective and efficient training for clinician scientists seems to occur when the clinical specialist training has been completed and the purpose and value of further research training is most clearly identified for specific career goals to be achieved. It is precisely at this point, however, that the sources of wastage are encountered.

First, a disappointingly large number of highly trained individuals come out of Ph.D. and M.D./Ph.D. programs unsuited to continue research in their chosen clinical specialty. This may be because of disenchantment with attitudes conveyed in the basic science laboratories or because of lack of progress or poorly chosen projects. Not infrequently, the area of research training is very narrow and has no obvious application to problems of clinical relevance. Some may become overwhelmed by the gap between the single-minded concentration of Ph.D. training and the very generality of the M.D training. For those for whom the Ph.D. and postdoctoral training has occurred prior to a full M.D. program internship and residency, the time that has passed away from the laboratory may seem too long and the science that they once knew has advanced too much for them to catch up. In all of these instances, there is either distaste for further involvement in research or reluctance to undergo further research training to correct deficiencies.

The outcome is often that the years of special research training are not utilized, and the money and time spent on training is wasted. This will continue as long as the Ph.D. and postdoctoral research training is routinely undertaken prior to completing the M.D. training, and the Ph.D. part of the M.D./Ph.D. program so heavily emphasizes research in pure basic science rather than in partnership with applied scientific disciplines.

It is therefore suggested that some NRSA programs be restructured to encourage a full or modified Ph.D. training program for physicians, focused specifically on the development of clinician scientists, and that this be encouraged as a change in attitude in all medical

research training areas. Success should be judged by the proportion of graduates of the research training program who continue to be engaged in research in their clinical careers. These are not new ideas, but it is my perception that some basic science laboratories are still operating on the principal of recruiting many trainees and relying on some form of Darwinism to determine which trainees will be designated successful, rather than trying to tailor the training to the abilities of the trainee and a broad vision of the problems to be solved in the future. A corollary to this would be to expect all M.D./Ph.D.s to enroll in a postdoctoral training program at the completion of their residency. If this became the norm it might lead to a more organized approach to career planning.

The second cause of loss of clinician scientists is financial. It has been stated above that the most effective time for research training in this context is after completing clinical specialists' training. While there are numerous social and psychological pressures that may persuade individuals from seeking further training at this time, the most common one has been the perceived urgency of the need to repay debts accumulated by college and medical school tuition. If some form of debt repayment, perhaps akin to community service that is currently under discussion for the community at large, could be devised for those committed to research training, it would certainly have retained a significant number of talented physicians in the past who were otherwise suited to become clinician scientists, but did not. This is perhaps the most critical decision time because essentially none of those who leave academic careers at this time are able to come back later, even if they would like to. A modest investment that would retain people at this time might reap exceptional dividends later. The current uncertainty about future funding and career opportunities is certainly exacerbating these difficulties, but a new partnership between the academic community, federal and industrial funding, and the national priorities is evolving, and this is part of this process. A research career is more fraught with insecurity than one devoted to clinical practice, and although there will presumably always be those who choose this path, it would clearly be wise not to drive away potentially effective clinician scientists by too adversely weighting the scales.

The third cause of loss of clinician scientists pertains to the striking loss of women. The anesthesiology residency program in my institution is probably typical in having approximately 30 percent women, and yet the number of female clinician scientists in the specialty as a whole remains small. This is not because of lack of ability, training, or interest, but first and foremost because of the extra responsibilities for child rearing and family matters that must still be shouldered by women. Those who have succeeded, in my experience, have done so with the help of a reliable relative or housekeeper, not just as babysitter or some other less experienced alternative, or have not had a family. It is not clear what the NRSA can do directly to correct this situation, but it does seem advantageous to recognize that it is a major factor in the failure of many professional women to fulfill their potential. Ways should be sought and remedies urged for this situation.

With minorities, the problem in my field is the small number of motivated and qualified individuals. Role models are probably important, although difficult to quantitate, as a basis for career decisions, and there are presently so few of them that they must appear more as the exception rather than as a realistic ambition. Progress is being made with the emphasis on programs for minorities entering into ongoing research programs and this should be encouraged.

In summary then, from my perspective, the NRSA Training Grant programs would be strengthened by encouraging more tuition reimbursement for trainees, emphasizing the collaborative aspects of basic science training for clinician scientists, enabling prospective Ph.D. candidates to complete the Ph.D. part of the training program and any postdoctoral work after the clinical specialty training, encourage industrial and commercial collaboration in training programs, and seek imaginative solutions to financial and family pressures felt by those engaged in training, which now extends into the fourth decade of their lives.

STATEMENT BY PAT MCCLOSKEY

I have two things I would like to share with you today. First are my concerns regarding the scientific job market. Secondly, I would like to outline a plan in which the scientific community can become a valuable partner in a community help program.

Foremost is my concern for the dwindling job market in science. If the current trend continues, then

I will become very anxious about my prospects for obtaining a job using my scientific skills. In fact, I know many scientists currently completing post-doctoral training who are having a very difficult time finding employment. No doubt the soft economy is playing a role in this but there simply does not seem to be enough demand to support the amount of scientists being trained. I do not believe that we can continue to produce scientists at the present rate and expect to be able to put their skills to work. Therefore, we need to tailor our recommendations for future training needs to coincide with what we anticipate as our future demand for scientists. In summary, a crisis is developing in science due to lack of funding and also to an oversupply of scientists. I suggest that we strongly consider future demand in our recommendations for training needs.

I share a view with many others that one of the largest demands for science will be in the technical fields. This brings me to my second point.

I have an idea that would help fulfill the need for competent technicians. More importantly, and I stress this point, the plan I have in mind would provide a means for the scientific community to reach out and help others. I believe it is important to try to help others less fortunate, and it goes without saying that the more we reach out to help others the stronger we all become. The program's aim is to provide a means for the less fortunate--and others who are caught in cycles of failure or dependency--with the resources to become self-sufficient. Many are minorities and women.

I would like to help start a training program whereby disadvantaged adults and disillusioned youths are (1) taught two or three well-defined laboratory skills over a period of about three months. (2) During the training period their living costs would be taken care of and, most importantly, they would be removed from their present set of circumstances and put into a supportive environment. (3) The key to the success of the plan is to have placement guaranteed upon mastering the techniques and completing the course. The long term goal is to endow individuals with defined skills which would then allow them access to entry level laboratory jobs in both academics and private industry. Once placed in the lab they would then have the opportunity to learn new techniques which would increase their value to the laboratory. I feel one of the best aspects of this plan is the opportunity for individuals to become self-sufficient and for them to be in a position where their own enthusiasm and initiative are allowed to direct their interests. This may result in the pursuit of a higher education in science.

To be more specific the training program would be a multifaceted approach to endow people with defined skills and enable them to have the poise and confidence to work in a complex environment. I stress the importance of a multifaceted approach because social and emotional stability are key to a positive learning environment. These individuals lack interpersonal skills as well as the ability to hold a job; often this is a reflection of poor self-esteem. It is impossible to address all these issues in a three month training course. However, in North Carolina programs exist that have already counseled individuals in the areas of self-confidence and interpersonal skills. These individuals are well prepared for the next step of learning new skills and entering the work force.

The first reason I feel this program can be successful is the people. In many cases, poor academic performance in high school is due to circumstances having nothing to do with the intelligence of the individual. In conversations with Dr. Finley Rush, Director of the Learning Opportunities Skills Center in North Carolina, I have learned that many of these people come from broken homes where education is simply not valued. Dr. Rush states that once these people are taken away from their negative environments, they often become highly motivated individuals. Intelligence is not lacking but rather the desire to pursue an education. Once these people are put in a supportive environment and given opportunities, they have proven themselves willing and capable students.

The second reason I feel this program can be successful is the support and enthusiasm I have received from educators, congressmen, and administrators. Preeminent amongst these supporters are those who have promised a position in their labs for people coming from this type of program. Many researchers feel that they want to do "their part," and so have promised apprenticeship-style positions in their laboratories. Though this is not a guarantee of employment, it is encouraging enough that Mr. Joel New, Director of the Department of Labor's Division of Employment and Training for North Carolina, was willing to pursue the idea and provide both personnel and funds.

What I am proposing is an investment in human capital. This kind of investment has received strong support from the President and he characterizes

apprenticeship-style programs as a top priority in his report "Putting People First. " I feel that this program offers an excellent opportunity for the scientific community to reach out and help those who are disadvantage. In turn, the program will benefit science by increasing diversity in the work force and creating links to new communities.

STATEMENT BY THOMAS J. MEYER, Ph.D.[3]

I am a research health psychologist currently in the second year of an NIMH-funded two-year post-doctoral fellowship in Mental Health Statistics at Columbia University. From my personal frustrations in attempting to develop as a researcher, I originally had three comments relevant to your question regarding the challenges in maintaining an adequate supply of scientists. I have added two additional comments with suggestions for improving conditions for lesbian and gay scientists, so that we may better focus on making our scientific contributions.

1. Funding levels for fellows are humiliatingly low, especially for city dwellers. As I celebrated my 40th birthday in the 7' by 11' dormitory room I lived in for my first 16 months as a postdoc, I had doubts about whether going back to school had been worthwhile. It struck me that my devotion to science was probably excessive to be sharing a bathroom with dozens of others at my age. Finances were so tight after I later moved into an apartment that until I started doing some consulting on the side, being able to afford groceries was a problem. Funding was even worse as a graduate student, but the problems were masked by the availability of student loans, which will soon be burdensome to repay.
2. The imbalance between the number of studies recommended for federal funding and the actual funds available has negative effects on budding researchers. Seeing many prominent scientists fail to get government grant funding so that they chase dollars from pharmaceutical firms of even the Tobacco Institute is not pleasant. Although fellows are supposed to be learning to compete for grants, the lesson we are learning may instead be that grant-funded research is a shakyenterprise, even if you have a constant stream of projects that your peers think have merit. Although my research skills are well-suited to a medical school, I am looking for more stable teaching jobs in psychology departments.
3. Social changes (and the lack of change in some locations) require reconsideration of the ideal that the scientist can move anywhere in the country to pursue "his" profession. Many of us who have suffered through the isolation of being a minority at a rural campus will not consider going to even the most prestigious institution where we would be separated from our reference group. Also, the rise of two-career couples restricts the options for many of us. In my case, I have not applied for any of the professionally enticing jobs my dissertation advisor has recommended me for in such gay-phobic locations as Memphis. Instead I will stay with my partner and risk the likelihood that I will be underemployed for some time, given the heavy competition for jobs in the New York metropolitan area. Since the cost of living is so high in the New York area, it is clear that even when I do get an appropriate academic job, I will need to moonlight, which will take away from my ability to focus on research projects of my own.
4. Enactment and enforcement of a federal civil rights law for lesbian and gay people and equal legal recognition of lesbian and gay relationships would help free us to focus more on our work and less on protecting ourselves from harassment and discrimination. I personally know of closeted scientists at a number of institutions, people who hear anti-gay jokes, fear dismissal, and feel the burden of hiding their lives. One of the first issues of the newsletter I received after joining the American Statistical Association last year included a notice about a group of anti-gay statisticians organizing to keep that society from passing a statement against job discrimination. Those universities that include sexual orientation in their published nondiscrimination policies have a recruiting advantage; we can tell where we are officially welcome and where we are not. Pending the extension of marriage laws to include us, it would also be helpful for departments to make it clear that same-sex partners are welcome at any social event for families. We could more easily relocate if our partners were included in family health benefits and if the job placement

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assistance given to heterosexual spouses were available for our spouses as well.

5. Prejudices against lesbian and gay issues as a proper subject of scientific study have led to a tremendous loss of talent in two ways. First, many have instead gone into private practice, and try to do studies in their so-called "free-time." For example, Laura Brown in Seattle would have made a wonderful faculty member, but was warned when applying for an academic job that she would never get tenure doing her work on ethical dilemmas and her work on egalitarian relationships, work with implications far beyond lesbian studies.

Second, many scientists like myself have deliberately decided not to focus on lesbian and gay issues because we fear our careers would suffer. Ethnic minority group members who are lesbian and gay have particularly felt the weight of this pressure.

The AIDS epidemic has made it clear that there is a need for researchers knowledgeable about gay issues, particularly with regard to ethnic minority gay people. It would be helpful to have some funds earmarked for lesbian and gay studies to encourage research in the face of prejudice.

Although there are substantial disadvantages in choosing a scientific career, I can still feel that spark of curiosity that led me to return to school at age 33 and dedicate the last 8 years to science. I hope that you will be able to use my comments in finding ways to make scientific careers less of a sacrifice and more appropriate to the realities of families of the 1990s.

STATEMENT BY PAGE S. MORAHAN, Ph.D.

It is timely for the National Academy of Sciences to formulate recommendations for the future of the National Research Service Awards program during this critical period for maintenance of preeminence in U.S. science. My comments are from the perspective of chair of a basic science department, past president of the Association of Medical School Microbiology and Immunology Chairs, and past and present director of research training grant programs and individual NRSA fellows. The conclusions are those of myself, our departmental microbiology and immunology faculty, and graduate students, and primarily address biomedical and behavioral sciences research in the academic or research institute setting.

Of the questions posed by the committee, the first appears the most urgent to address: *"What is the most significant challenge we face today in the U.S. for maintaining an adequate supply of qualified scientists to sustain and advance health research?"* It will not be fruitful to address the other issues (improvements in the NRSA program, effectiveness in recruiting women and underrepresented minorities, higher quality training environments) until the major underlying challenges are addressed.

The top three challenges that we identify are:

Lack of security. This is the number one problem identified by both the faculty and graduate students.

- The uncertainty of being able to practice one's profession is having a serious detrimental effect at all levels - on experienced researchers, new researchers, research trainees, and on those considering research as a career. At the graduate school level, this issue greatly affects the research areas and specific projects that a student chooses. At the professorial levels, the ability to do one's research has been the driving force that has attracted and kept individuals in the research profession, and which usually does not bring rewards similar to those that can be obtained in other professions that require equal or less training time.
- The uncertainty has a much broader ripple effect than generally appreciated. It affects the choice of career--academics versus industry or government laboratory. It affects one's personal life, for example, the ability to apply for mortgages and to obtain loans, and the comfort with which one makes major life decisions. It is my perception that the practice of research science requires a complex blend of discipline and creativity as seen in artists and musicians; similarly, most scientists want to practice their craft and not be concerned with questions of yearly survival.
- The uncertainty is greater than in other professions where academicians must bring in a substantial part of their salary from practicing their profession. Each research grant makes up a significant portion

of one's salary (20-50 percent); therefore, the loss of one grant results in a devastating effect, whereas the loss of one patient or client generally results in less effect for a physician or lawyer. The increasing pressure to bring in a greater percentage of salary from grants only exacerbates this problem.

- The problem is compounded by the increased competition for funding. Scientists often are not comfortable with the reality of being in life to death competition with colleagues.
- Lack of sufficient start-up funds and time to ensure success at the beginning of one's independent career was also viewed as a significant problem.

Lack of reward as compared with physicians, engineers, and business managers. Lack of security, coupled with lack of financial reward, has produced a downward spiral. Some scientists could accept the present uncertainty of practicing one's profession, if the rewards were commensurate with the risks. Faculty viewed the reward issue as equal to the above challenge, while graduate students felt the next challenge (lifestyle demands) was even more important.

- Research scientists achieve less financial reward than professions that require comparable training time (now averaging a total of 5-6 predoctoral years, and 5 postdoctoral years before becoming an Assistant Professor). Support during the training period and reasonable certainty of research funding thereafter have been major factors that have attracted talented people into research science instead of other professions such as medicine and engineering. Both of these factors have seen major erosions. Strategies that might lead to shorter training periods could be redefinition of the content required in our curricula, recognizing that much of it will be outdated in five years, and that there is increased need for life long learning skills. Another strategy might be to redefine dissertation requirements, emphasizing writing of papers and other scholarly pieces of work.
- In research science, there is less of a direct correlation between the amount of time spent and reward, unlike other professions such as medicine and law. If you treat more patients or have more clients, there is a correlative increased reward. In research, increased numbers of grants generally merely means more salary is covered by the grants.
- There is considerable inconsistency among schools and research institutions, and between disciplines, regarding salaries, teaching, and service responsibilities, etc.
- Time for the integrative reflection and creative thinking required for break-through science is highly valued among scientists, and this reward is being eroded. There is insufficient time for this now, associated with increased pressure for increased productivity (more publications, more grants, etc.)

Lifestyle demands. In order to be successful, biomedical and behavioral academic scientists must be workaholics.

- Work addiction is no longer accepted as the norm in this era of interest in self-actualized careers, increased cultural diversity, and increased numbers of women in the profession.
- Unlike many other comparable professions, one cannot leave research science for much longer than a year and still remain competitive. Increased flexibility for retraining in NRSA programs might be a useful strategy to address this issue. It is difficult to train on a part-time basis, unlike many other professions. Increased flexibility for training grants to educate part-time students could be a useful strategy.
- There is a requirement for rapid, lifelong learning to keep up with major technologic changes; many consider this requirement to be more intensive for research science than in comparable professions.

While the three areas above were viewed as the major challenges, several others were viewed as important.

Loss of researchers at all stages of the pipeline. There is the well recognized loss of potential researchers in the K-12 years; the factors are complex and include both peer pressure views of scientists as "nerds" and poor teaching of science that destroys

children's innate interests. In addition, there is an increasing trickling out of trained scientists from active research. Some move into new careers (e.g., scientists into patent law) that do not involve active research. Others leave science altogether; this is often true of women who leave to raise families and find that they do not wish to take the time and lower positions required for traditional retraining. Various strategies can be considered:

- Better training and continuous re-training for teachers of science in K-12 grades.
- Development of widely seen TV shows that picture scientists as normal people (sitcom series?!)
- Development of widely visible materials on the spectrum of full-time and part-time career opportunities available for scientists.
- Induction training at the Assistant Professor stage in order to develop a community of scholars who can be a support group and network for each other in the "business" aspects of the research profession; this can include both training at the institutional level and nationally through linkages enabled by E-mail and other electronic strategies.
- Development of additional types of retraining programs and scientific careers that could be pursued on a part-time basis. Innovative programs with industry might be helpful, funded by a general industry fund, with those completing training going into that industry. The period of retraining should be shorter than that of original training, thus enabling industry to fill shortage areas more rapidly.
- Opening up NRSA training to foreign nationals; this would recognize that many stay in the U.S., and that the movement to a global information age and economy will increase the opportunities for international scientific projects.
- Institutions could institute an additional professorial rank that recognizes the senior scientist who remains at the bench and does not choose to pursue administrative positions.

Increased emphasis on applied research or other service oriented responsibilities is inimical to scientists' basic values. The predominant value in science is the abstract ideal that increasing knowledge is good for mankind in general, for the scholarship of discovery research (as defined by Ernest Boyer, Carnegie Foundation). A change in the culture of what scientists value is therefore needed--to a broader view of scholarship that includes application scholarship (including applied research and nontraditional scientific careers), integration scholarship, and teaching scholarship. Strategies might include:

- Projects in scientific disciplines to redefine the meaning of scholarship in their disciplines, as has recently been done by the American Chemical Society.
- Programs to allow for scientists to move into industry or teaching and to move back into academics--a breaking down of the barrier that teaching or industrial science are less respected in the profession than is discovery research. After Ph.D. training there are options that generally dictate the rest of one's career--a postdoctoral fellowship will keep one in the pipeline for academia and research institutes, while choosing a teaching or industrial position precludes going back.
- Change in study sections to more interdisciplinary review. This could help educate scientists about the different types of scholarship, and increase their appreciation for the different approaches in science used by different disciplines (e.g., molecular, clinical, systems, behavioral).
- Projects to determine the specific training needs of industry or other potential employers of scientists, and reform current training programs to meet those needs, and to enable students to be more adaptable to whatever careers in which they find themselves. Are current Ph.D. scientists trained sufficiently in dealing with research regulations, electronic communication techniques, communication skills with "lay people", research personnel, and financial management skills, writing skills, teaching skills, etc.?

Detrimental impact of increased regulations on creative scientists. The increase in all kinds of regulations (e.g., safety, bioethics, financial reporting) is seriously dampening the desirability of the scientific research profession. The emphasis on inspection rather than preventive measures is particularly to be deplored.

Not all of the above areas can be addressed solely by the NRSA program, yet many can be. One major approach would allow more flexibility in programs, and incentives to pilot innovative programs. An example might be inter-institutional training grants which benefit from the broader expertise of scientists, provide students with the opportunity for wider peer review as they take courses at other schools, provide more efficient use of faculty in teaching, and provide for sharing of equipment. An associated approach would be to have yearly meetings and electronic communication linkages among training grant directors to rapidly diffuse ideas that "work", and share information on managerial issues (e.g., longitudinal database software, meeting organization procedures) to reduce unnecessary competition and re-inventing the wheel.

STATEMENT BY SUSAN PERSONS

My name is Susan Persons, and I am the Associate Director of Government Affairs of the Consortium of Social Science Associations (COSSA). COSSA represents over 90 professional associations, scientific organizations and universities. We welcome the opportunity to comment on ways in which the National Research Service Awards program might be strengthened to advance health research in the U.S.

Identifying the most significant challenge for maintaining an adequate supply of qualified scientists to sustain and advance health research is not difficult. Clearly, the most critical issue is funding. For several years the budget for training researchers has not increased, resulting in the elimination of training slots, and the inability to fully fund existing slots. Eliminating training slots obviously decreases the number of scientists for the next generation. Underfunding the slots has various deleterious effects, including making training inaccessible to some people, and diverting the energies of training directors, as they are compelled to spend time seeking additional funding, rather than concentrating on the substance of the training program.

Although your request was to identify the single most significant challenge to maintaining qualified scientists, I would be remiss if I did not at least mention two other very important challenges. First, ways must be found to channel research training opportunities to those disciplines with the most need. Nursing research, for example, is experiencing dramatic growth, while most of the cadre of nurse scientists will be of retirement age in 15 years. Adequate funding for research training is imperative in order to permit a sufficient number of qualified nurse scientists to be available to conduct health research. There is also an urgent need for doctorally-prepared nurses just to meet the basic need for doctorally-prepared faculty. In nursing baccalaureate and masters programs, nondoctorally-prepared faculty comprise 55 percent of the total. In doctoral programs, the percentage of nondoctoral faculty ranges from 76 percent to 0 percent, with an average of 37 percent.

Second, it is important to recognize that the population of the United States is changing rapidly, and as new health concerns arise, new training will be required. For example, as the population ages, we will face new demands on health care, social security, pension plans, and social service needs. We cannot rely on a continuation of existing disciplines and the training opportunities within them. Instead, we must seek aggressively the kinds of training programs that will generate scientists knowledgeable and skilled in these changing problems. New research will be needed to estimate the long-term care needs of different ethnic groups, calculate how changing technologies will contribute to health care costs, explore new ways to keep frail older adults living independently at home, find ways to make the workplace friendlier to older workers, and explore the housing needs of new cohorts of older people.

Two primary factors that influence the continued availability of investigators are trainee stipends and program flexibility. Few would dispute that in order to attract participants, stipends for training awards must increase. As you know, the stipend for the predoctoral NRSA is below the poverty level. Students are required to devote 40 hours per week to research training, but must also hold down a job to supplement their incomes. An extended 60-80 hour workweek for a period of several years is plainly not an incentive to

continue a career in research. When stipends for postdoctoral positions are not competitive with beginning faculty salaries, it is easy to see why faculty or other positions are more attractive, and the result is a loss of skilled researchers.

Increasing flexibility within the NRSA program is also key to assuring a continued supply of investigators. Access to predoctoral and postdoctoral training throughout the country and in varying types of institutions is needed. The current distribution of training programs is limited primarily to bicoastal areas. Also required are greater interdisciplinary training opportunities to address increasingly complex social/health problems. For example, in the social sciences, we need demographers and sociologists trained in aging research, epidemiologists with a background in economics, and economists sensitive to aging issues. As another example, psychologists researching health-related concerns need to interact with engineers to help frail older adults living independently at home. And as new technologies evolve, health researchers must have the flexibility to shift their research focus.

Increasing the flexibility of the NRSA program will be especially helpful in increasing the participation of women and minorities in scientific careers. Women and minorities often are less geographically mobile than men. For example, nursing is working to establish a postdoctoral tradition for scientific training, but many nurses are unable to take advantage of training programs because of the limited locations of the programs. Of the 54 nursing doctoral programs, only 15 have institutional research awards. Efforts to locate individual and institutional training programs where women and minorities can more easily access them will do a great deal to increase their participation.

Understanding the social context of women's lives is critical to increasing their participation in research careers. The career paths of women and minorities often are interrupted by family demands and economic factors. Women still have the primary responsibility for child care, for maintaining the home, and increasingly, for the care of elderly family members. Adapting the NRSA program so that it takes into account the reality of women's lives is a necessary prerequisite to increasing their participation. Developing mid-career mechanisms that would allow women to reenter their research career after absences is one strategy you might consider.

In order to assure a high quality research training environment, we offer the following suggestions: First, it is important to recognize that health-related research is being conducted increasingly by multidisciplinary teams. Therefore, the fact that current training award mechanisms often produce scientists without this experience is a major concern. Training mechanisms need to encourage training breadth to prepare current and future researchers from different disciplines to work with each other in addressing increasingly complex scientific and technological issues. A wider research focus, along with experience working in multi-disciplinary teams, will prepare researchers to work in tandem with researchers in industry, academics, and research centers.

Second, individual and institutional NRSAs should continue to be offered to ensure access to training and a broad distribution of scientific researchers. We can no longer afford to ignore smaller institutions and rural areas and waste opportunities to attract and train additional local scientists.

Although adding additional costs is very difficult in these times of tight budget constraints, we urge that consideration be given to providing mentor salaries on training grants. The incentive of paid time to supervise a training program can make the critical difference in establishing a new interdisciplinary program where the mentors themselves must cross disciplines and department lines in order to build and maintain the program.

Lastly, we recommend that provisions be made for site-visiting institutional training award applications. Though we realize it would be impractical to site-visit all applications, a routine provision for site-visiting large Type 1 applications would do much to ensure a high quality review of the training environment.

STATEMENT BY CORNELIUS J. PINGS, Ph.D.

It is a pleasure to appear before you today on behalf of the Association of American Universities (AAU) to offer our views on the future training needs for biomedical and behavioral scientists.

The AAU represents 58 research-intensive universities where much of the research training of predoctoral and postdoctoral students in all disciplines takes place. The National Research Service Awards (NRSA) Program has provided a large portion of the funding needed to support these students and, as such,

is a program in which the AAU has a great deal of interest. The AAU believes the NRSA Program is well designed, well administered, and very effective in assisting high-quality graduate programs to attract talented students into graduate study and assist them in completing that study. Although I do not think that any major programmatic changes in the program are called for, there are a number of modest changes that the Committee might wish to consider.

First, in my view, the most significant challenge we face today in the United States for maintaining an adequate supply of qualified scientists to sustain and advance health research is the provision of sufficient, stable resources for the overall biomedical and behavioral research enterprise. While it is true that federal funding for biomedical and behavioral research has increased over the past years, there are other factors that should be considered when evaluating how stable and predictable the research budget has been and will continue to be in the future.

Throughout the 1980s, the Reagan Administration attempted to cut funding to the National Institutes of Health (NIH). While these proposed cuts were consistently rejected by Congress, providing adequate funding levels for the NIH became an annual budget battle that created a great deal of uncertainty among the biomedical community. Even when proposed cuts were rejected and increased funding was provided, there was still a significant shortfall in dollars needed to fund many qualified grant applications. Today, the NIH only funds approximately 18 percent of its approved grant applications. Even those grants that are funded receive significantly less than the dollar amount requested and approved by the NIH Study Sections. This scenario has resulted in individual investigators applying for multiple grants on a variety of funding cycles, constantly wondering if the dollars will be there tomorrow for the research that is started today.

Some of these concerns were intended to be addressed by the NIH Financial Management Plan issued by the NIH in June of 1991. According to the Plan, “Stability and predictability in the aggregate funding level for biomedical research are essential to maintaining the momentum in knowledge advancement that results from our investment in biomedicine. They are also essential to reassure scientists that their years of training will result in reasonable competitive opportunities to pursue and maintain a research career.” The plan identified a Biomedical Research and Development Price Index (BRDPI) that could be used for an accurate and realistic assessment of inflationary growth in biomedical research costs. Unfortunately, the NIH budget has not even kept pace with the numbers recommended in the NIH Financial Plan, and the overall concern about the adequacy and stability of the NIH budget is still very real among the biomedical research community.

It is also worth noting, Mr. Chairman, that government restrictions on certain kinds of research, particularly in the behavioral area, have also sent a very discouraging message to future scientists interested in behavioral and social science, as well as other areas of research such as fetal tissue transplantation. As you know, President Clinton has lifted the ban on federal funding for research on fetal tissue transplantation, but the ban and other restrictions that were imposed on research in the past can have a chilling effect on future research and young scientists.

Of course, more money for research is not the sole answer to attracting talented graduate students to a career in biomedical and behavioral research. Nor does it look like an answer we should be relying on to solve all of our problems. As the President’s Council of Advisors on Science and Technology recently reported in “Renewing the Promise: Research Intensive Universities and the Nation,” “A realistic assessment of the next several decades indicates,…that no matter how firm our national resolve may be to invest in the future, resources will not expand as rapidly as our intellectual capacity to pursue promising research opportunities.” Given that prospect, the only responsible approach is for the nation to decide what size research enterprise it is willing to support and then to provide the level of federal support that will maintain that enterprise at the highest levels of quality and assure the training capacity necessary for its continuation.

As I indicated earlier, the NRSA Program is an extremely effective mechanism for assisting universities to meet the nation’s biomedical training needs. Perhaps the single most important improvement in the program would be to increase the training grant stipend. Most universities augment NRSA stipends, requiring them to divert resources from other university functions. When universities are unable to augment stipends, trainees are forced to take out loans or work to meet their living expenses. Loans increase the already considerable debt burdens incurred in undergraduate education, and work draws students away from their academic program, extending their time to degree. The NRSA stipend is well below those provided in other federally funded

service fellowship programs. Even the Department of Education fellowships were increased last year to match NSF fellowship stipends currently at $14,000 annually.

The Minority Access to Research Careers (MARC) Program has proven to be highly effective in drawing talented minority students into careers in biomedical research. The program should be strongly supported and perhaps increased in size. According to the NIH, in 1990, over 5,000 doctorates were awarded in the life sciences in the U.S., but only 2.3 percent went to Hispanics, 1.4 percent to African Americans, and 0.2 percent to Native Americans.

Many universities have used the MARC program to identify promising undergraduates and provide them with summer research internships and related activities to interest them in and prepare them for graduate study. The quality of the research program and the extent of faculty mentoring are major determinants in the success of institutional programs, and these attributes should continue to play a determining role in awarding grants in any expanded program. In addition to expanding the MARC program, the committee should also consider opportunities to expand and increase the flexibility of incentives for principal investigators to hire minority graduate and undergraduate students.

While women now receive about one-third of the Ph.D.s granted, they still remain underrepresented in science and engineering. Mr. Chairman, I would encourage this Committee to consult with the Office of Research on Women's Health at the NIH to explore ways in which the NRSA program might encourage more women to consider a career in biomedical research.

Finally, one of the features of the NRSA training grant that might be strengthened to assure the maintenance of high quality research environments is the need for institutional flexibility in allocating the resources that accompany each grant. In addition to providing critical support for students, training grants should continue to provide significant resources for strengthening and sustaining the training programs themselves. The Committee may wish to consider permitting a flexible rather than a fixed proportion of training grants to be used for program support. However, care must be taken to assure that any increased proportion of training grants used for program support be fully justified on the basis of the overall benefit to training capacity of the program, and clearly differentiated from objectives better supported through research funding.

To increase NRSA stipends to a competitive level while maintaining the same number of trainees in the program will require a substantial increase in program funding. I fully understand how difficult this will be, given the constraints on the NIH budget. I suggest, therefore, that you phase in the necessary increases over perhaps a five-year period.

STATEMENT BY JOANNE M. POHL, Ph.D., R.N.

There are three areas I want to address to assure a continuing supply of skilled investigators in the biomedical and behavioral sciences: 1) the need for interdisciplinary and team research including multi-university relationships; 2) increased attention to the educational needs of women and minorities; and 3) strengthening financial support and allowing more flexibility regarding employment stipulations.

First I will address the need for interdisciplinary and team research and cross university relationships. My recommendations here are three fold: 1) more emphasis on cosponsors and interdisciplinary sponsors; 2) financial support for consultants from smaller or lesser known universities; and 3) some sort of "match" system with faculty across disciplines and universities.

The need to mentor younger and newer scientists is clearly critical and, as funding becomes increasingly competitive, senior researchers find that they have less and less time to devote to mentoring. Senior researchers and faculty need both time and rewards for mentoring younger researchers. One alternative may be to share the mentoring when that is possible.

For example, one of the strengths of my NRSA was that I had not only two cosponsors from The University of Michigan--each from a different discipline and with complementary skills, but also I was able to utilize the mentorship of a research team at another university, Michigan State University, because of my employment there as a research associate. My mentoring occurred across disciplines and across universities. This cooperation is unusual I am told; yet, this broad perspective was mutually beneficial at every level. The responsibility for mentoring was shared, and each one of us had the benefit of interaction with other experts in my particular field of research.

Cosponsors need to be the rule rather than the exception. The traditional model of a solo researcher

providing the mentoring for selected students may have its place in certain instances. But in order to assure the maintenance of high quality research training environments especially in the behavioral sciences, I would like to see more support for interdisciplinary and team efforts and even multi-university cooperation. The problems we are researching today in behavioral science often demand an interdisciplinary approach. Collaboration needs to be modeled for students. The concept that research in a particular area is the work of one or two persons fosters isolationism and competitiveness which is no longer appropriate to scientific development; it is not conducive to learning nor to the multiple roles many of us assume in academia.

Qualified scientists may be in smaller or lesser known universities, or have limited access to advanced graduate students and postdoctoral students. It is possible that these scientists could play an important role in mentoring young researchers, and fees for their consultation might be incorporated into NRSA funding, similarly but perhaps on a smaller scale, to that done with academic awards and RO1s. Such contacts early in someone's research career can be critical as one begins to develop those important broad linkages. This relationship could be highly advantageous to a smaller or less prominent university as it attempts to respond to the research needs of this country.

In addition, some sort of "match" system may be advisable in areas of high need research; a match with faculty in another university who might provide significant input into the student's research program might be useful.

The needs of women and minorities have been identified as an area of special concern by this committee, and this is the second area I want to address. There are gender differences in the timing of graduate education based on long standing social traditions. Many women enter the graduate track later in life due to family care responsibilities, second careers, and often develop first careers later in life than men. Many of these women are single parents. The NRSA needs to reconsider its limited support structure if increased participation by women and minorities is a goal. More options are needed. For example, incentives for completing early may be appropriate for some, while others need support for additional years with funding spread out over that time and with the student allowed more employment hours than is presently the case. I will make more specific comments on the funding issues in the third and final section of this report.

To assure a continuing supply of skilled investigators in the biomedical and behavioral sciences I believe we need to expose promising undergraduate students, especially women and minorities, to research early in their educational experience through creative course work and independent study.

- Programs such as the Summer Research Opportunities Program at The University of Michigan which allows young women and minorities to work with university researchers, for pay, during the summer, may be critical for attracting young researchers.
- Recently women's groups have suggested that daughters spend a day at work with their mothers. That concept may need to be taken seriously on a broader scale. To recruit women into research we need to suggest that high school students and college undergraduates spend not a day but a term with a woman or minority researcher.
- Incentives to universities and faculty who encourage and sponsor students in these sorts of programs are needed. Linkages may need to be developed across universities as already suggested. We might invest more doing this, but the overall product would be worth it.

The third and final area I want to address is that of funding. Although I am grateful for the funding that accompanied my NRSA, I and many of the other women doctoral students at The University of Michigan found the stipend and rule regarding employment extremely limited. Cost of living in Ann Arbor for one is estimated to be $1100 per month by the university. Many of us are parents, some single parents, and some of our children are in college so education costs are often not just our own. The existing structure of a $700 monthly stipend and employment limitations to 25 percent time is simply not sufficient. If the stipend cannot be increased, then I would strongly urge that employment limits be lifted and the NRSA annual progress report be the basis for evaluating productivity and continued financial support. The assumption seems to be that work is not educational and may interfere with educational productivity. In my case my work was part of my mentoring experience and was critical to my progress.

In addition, early completion might be rewarded. At the present time there is no incentive to complete one's course of study early. I was able to complete my dissertation and end my NRSA grant one year early. I worked very hard to match the end of my second year of funding (December 30th, 1992) with the end of winter term at the University (December 15th). However, to meet the deadlines at The University of Michigan for December graduation, I needed to defend my dissertation late in October using November to make changes and meet all the graduate school requirements for a December 15th graduation. I am now told that I need to pay back my December and part of my November stipend. This seems counter-productive to the aims of the NRSA. Students may continue to receive funding year to year with minimal annual review. Yet, when students finish on time or early, there may be a fine rather than a reward. I would recommend an annual evaluation that seeks clearer evidence of progress that is congruent with the stated plan.

Another funding concern is the lack of health insurance for students. This is obviously a hot issue right now in our country, and hopefully will be resolved nationally. However, it is an issue now for NRSA awardees, especially single parent women who cannot qualify for health benefits through their employer because they can only work 25 percent time or less.

And finally, a comment on the institutional versus the individual award. The individual NRSA award is often thought to be more prestigious, yet, it does not have tuition included as does the institutional award. It would seem reasonable to equalize the awards and cover tuition for both.

I close by thanking you for the opportunity to have been an NRSA awardee and to have shared my insights today. The University of Michigan provided a very stimulating research environment for me as a student-and continues to do so presently as I now, as an assistant professor, continue my research.

STATEMENT BY DOMINICK P. P URPURA, M.D.

I am Dominick Purpura, Dean of the Albert Einstein College of Medicine and Past-President of the Society for Neuroscience. On behalf of the Society for Neuroscience's 22,000 members I am pleased to have this opportunity to address issues immediately relevant to the recruitment, training, and employment of young investigators in the brain and behavioral sciences. I view these issues from several perspectives; as a neuroscientist whose research career began 40 years ago with a special fellowship from the National Institutes of Health, as an investigator, mentor and director of training programs, and now as Chief Executive Officer of a research intensive medical college that has made a strong commitment to basic biomedical and behavioral sciences research and research training since its founding. I shall limit my remarks to the brain sciences as a neuroscientist, Past-President of the Society for Neuroscience, and current President of the International Brain Research Organization. I am a member of the National Academy of Sciences and its Institute of Medicine.

Neuroscience is truly the most rapidly growing biological growth industry in the life sciences. Young people fascinated by the prospects of understanding how we think, how we behave and who we are, look to careers in neuroscience to make fundamental contributions to the human condition in health and disease. They are cognizant of the extraordinary opportunities available as a consequence of the application of molecular and cell biology principles, molecular genetics, computational sciences, and the more traditional disciplines of morphophysiology and experimental psychology to studies of brain structure and function. But they are also aware that these opportunities are threatened by real and perceived difficulties affecting even the most established neuroscientists who despair of obtaining adequate federal and private funding for their research projects. The first twelve words of Charles Dickens' classic, *A Tale of Two Cities* are: "It was the best of times, it was the worst of times...." These words say it all. Never in the history of humankind have we been so close to understanding how the brain works to produce mind. The best and brightest of our young scientists know that unraveling the mechanism of brain function and the processes by which these go awry, can enrich their intellectual lives and provide a life of meaningful inquiry and professional satisfaction. It is indeed "the best of times" for neuroscience. But the climate of impending contraction and zero-growth in NIH-NSF budgets which pervades all academic institutions today portends "the worst of times." Like the residual low-level background radiation of the Big Bang that permeates the Universe, the question one hears

throughout academia is “How will I support my research career?” I submit, in response to the Committee’s first question, that *the most significant challenge we face today for maintaining our adequate supply of qualified (neuro)scientists to sustain and advance health research* is to provide a rational mechanism for ensuring stable support for young scientists as they begin and progress through their academic careers. To achieve this will require reaffirmation of the importance of universitygovernmental covenants concerning sponsored research and a mechanism for stabilizing the support of productive investigators.

Facilitating research opportunities by enhanced availability of grant awards will permit highly motivated young men and women to realize their career goals in the biomedical and behavioral sciences. Neuroscience is fortunate in the magic of its appeal to the inquiring young mind. We have been blessed with literally thousands of young graduate students and postdoctoral fellows who are associate members of the Society for Neuroscience. And we are particularly proud of our minority recruitment program, the number of women who are neuroscientists (approximately 30 percent), and the fact that two women have been President of the Society in the past decade.

The Commission has posed the question as to *what improvements might be made in the NRSA program to assume a continuing supply of skilled investigators*.

Acquiring the necessary skills to become a competitive scientist in today’s highly technical biomedical research community requires in-depth experience with a wide range of techniques under the tutelage of experienced mentors in collegial and collaborative settings. Pre- and postdoctoral trainees are avid consumers of faculty time and institutional resources. In better times, sponsors of trainees utilized funds in their research awards to provide supplies and equipment for their graduate students and fellows. Institutions have provided stipend supplements, and, in many instances, subsidized housing. As the costs per grant escalate in the face of reduced award levels for the vanishingly few successful applications that attain threshold for funding, it can be anticipated that training will be seriously compromised. The NRSA program could be significantly improved by allocating sufficient funds to cover the true costs of laboratory and living expenses incurred during training. The stipend level for pre- and postdoctoral fellows should be examined to ensure subsistence capability. Current levels of NRSA fellowships are not realistic in today’s economic environment, particularly in the Northeast.

Training of neuroscientists requires more attention to the nature of the field in inquiry than is evident for training in biochemistry, molecular biology or genetics. This is because neuroscience is not a discipline as such, but a way of thinking about how to approach problems of brain mechanisms. Competent neuroscientists utilize the canon of knowledge and techniques in neuroanatomy, physiology, neurochemistry and other disciplines including molecular genetics. While maintaining a sharp focus on acquiring one or two disciplinary skills, they must also keep their peripheral vision on the wide range of disciplines that impact on brain research. Indeed the successful neuroscientist has operational knowledge about the structure and function of neuronal systems from “molecule to behavior. ” It follows that institutional programs supporting NRSA fellows must be of the highest quality to provide the critical environment for high achievement.

The problem of enhancing opportunities for women and minorities in NRSA programs will be satisfactorily addressed when there is an appropriate increase in the number of women and minority persons in positions of mentorship in academic and industrial settings. Equally important is that there be women and minority support groups that are visible and integral components of the sociological environment of institutions providing training. Child care support, resetting the tenure clock, maternity leave, and other related issues can be instrumental in facilitating the needs of young women in academic science careers. But none of these efforts will succeed in the absence of evidence that trainees will not be penalized with loss of mentor-bonding should they decide to substitute the joys of maternal-infant bonding for a brief period in their training program.

The number of minorities in science will be increased when K-12 education is improved in urban settings so as to encourage minorities to pursue academic programs and when undergraduate education ensures science literacy and instills a thirst to create as well as absorb knowledge. Increasing the number of minorities in high school and college programs of summer research in our training institutions will expand the pool of qualified candidates and help influence career decisions relevant to biomedical research. The Association of Medical Schools of New York has had such a program in place for many years with a creditable record of achievement. Training program

directors must also be encouraged to expand their outreach to minority students.

It should not escape our attention that the most endangered species of biomedical and behavioral sciences investigator is the individual who is emotionally and intellectually prepared to pursue at least seven years to attain the combined M.D./Ph.D. degree. There is a desperate need to encourage the best of our students to prepare themselves for academic careers in medicine particularly in the transfer of new knowledge from the bench to the bedside or whatever setting will be forthcoming in the future. American medicine is in the throes of a "Healthquake" of Richter 7-8 proportions and there is the danger that biomedical research involving M.D./Ph.D.s will be trapped in the rubble. Attention must be paid to this problem lest we bear witness to the withering away of the most successful program for creating a cadre of physician-scientists the world has ever seen. I am proud to note that several of the M.D./Ph.D. students trained in our neuroscience program at Einstein have attained Professorial rank including Chairmanship status. Similar successes have been recorded in other M.D./Ph.D. programs throughout the nation. In this era of special concern for transforming the benefits of basic laboratory research to the clinical domain the well-trained physician scientist will play an ever-increasing and important role.

Finally, the Committee has solicited opinion as to whether enhanced employment opportunities in industry might require new research training strategies in neuroscience. There has indeed been a proliferation of variable size start-up companies aimed at the development and production of neuroscience related pharmaceuticals and other treatment modalities. Highly skilled molecular or integrative neuroscientists are being sought for these companies, including the more established pharmaceutical houses. In-depth, highly focussed post-doctoral training should prepare most trainees for these positions. But there should be no attempt to bias the predoctoral or postdoctoral training experience in relation to the potential for industry-based employment. A well-rounded, motivated, and skilled neuroscientist should be the product of an NRSA program. Whether a trainee elects academic or industrial employment should not be preordained by the nature of the training program, per se. Even in a post-Marxist world, economics will remain a powerful determinant of human behaviors.

STATEMENT BY IRWIN SANDLER, Ph.D.

I'd like to address training needs in a newly emerging multidisciplinary area, prevention research. Over the past several years I chaired a panel on training needs in the area of prevention for the NIMH sponsored National Conferences on Prevention Research. Our panel was impressed with the exciting promise of this field and with the considerable needs for training researchers in this area. The issues we considered overlap with many of the questions you are addressing, and I believe that it is important that you consider them in your deliberations. I am also co-Principal Investigator on an NIMH funded Institutional Training Grant in Prevention Research. My comments will also reflect this experience.[1]

Research on the development of preventive approaches to mental health problems has emerged as an exciting part of the country's biomedical and behavioral sciences agenda. The need for a preventive approach has been stimulated in part by the high prevalence of mental health problems. For example, 12 percent of children under the age of 18 are conservatively estimated to suffer from a mental disorder;[2] 22 percent of pediatric patients seen at a health maintenance organization are found to have one or more clinical-level DSMIII disorders.[3] There is also encouraging evidence that well conceptualized prevention programs can be rigorously tested and found to have positive benefits to prevent mental health problems.[4,5] Research in prevention presents numerous scientific challenges. The skills of multiple disciplines are required to study the biopsychosocial factors which lead to the development of mental health problems over time and to design and evaluate scientifically rigorous trials of approaches to prevent these problems.

Evidence for the emerging significance of prevention research can be seen in the fact that the National Institute of Mental Health has sponsored three National Conferences on Prevention Research over the past three years and the Institute of Medicine is currently conducting a comprehensive review of the status of prevention research. One of the central needs that emerged from the National Conferences on Prevention Research is the critical need for increased training of scientific manpower in this area. Currently there are only two training programs in prevention research funded by NIMH, which currently support a

total of five postdoctoral fellows and one predoctoral trainee. We are in danger of failing to train the needed scientific manpower for prevention research.

I'd like to briefly address four issues concerning the need for training of prevention research scientists. What do prevention researchers need to know? Who should we be training to pursue prevention research? What kinds of National Research Service Awards are needed to meet the training objectives? What steps are needed to improve the effectiveness of the NRSA program to recruit minority researchers?

What do prevention researchers need to know?

Prevention research is intrinsically a multidisciplinary effort. The conduct of prevention research requires a wide range of substantive knowledge, methodological sophistication and practical skill in working with community settings. Prevention researchers need conceptual and theoretical sophistication in the development of mental health competencies and mental health problems. This understanding needs to be well grounded in an epidemiological perspective and in an understanding of normal and abnormal developmental processes. This knowledge base forms the theoretical underpinnings for the design of preventive interventions. Prevention research must involve the design and evaluation of new models of intervention to correct pathological development processes, thereby reducing the incidence of mental health problems. In order to develop and apply effective interventions, researchers must be knowledgeable about the ecology and culture of the settings in which their interventions take place. Prevention researchers must be able to develop collaborative relations with community settings so that the interventions, if successful, will be continued. Prevention research requires the use of the most sophisticated methodological and statistical techniques in order to reach valid inferences. Methodologists are needed who can develop the new statistical techniques to solve problems in data analysis and who can bridge the gap between developments in mathematical statistics and applications to prevention research questions. Since prevention research is usually conducted by teams of researchers, it is not necessary (or possible) for all scientists to be equally strong in all areas. However, it is often necessary for a researcher to have a superior background in several of these areas.

Who should we be training to do prevention research?

Training in prevention research should occur across disciplines and across predoctoral, postdoctoral and mid-career levels.

Predoctoral training in prevention can occur in a wide range of fields such as public health, social sciences (e.g., clinical, community and developmental psychology, sociology), quantitative methods in the social sciences and biostatistics, psychiatry, family studies, nursing, or social work. These fields provide an excellent disciplinary base from which scientists can develop careers in prevention research.

Postdoctoral training is an important way in which individuals who receive traditional training in a discipline can develop a special focus on prevention after their degree. The expected result should be the development of prevention specialists within multiple disciplines and the cross-fertilization of the skills and perspective of multiple disciplines in prevention research.

A very important alternative to early training is to involve mature scholars from related fields to integrate their expertise with prevention research. The training of mature scholars in prevention can provide a rapid mechanism to apply important concepts and methods from multiple disciplines to critical prevention research issues. Such individuals need immersion experiences in prevention research to increase their understanding of the issues and to draw them into the field. They should be offered flexible training opportunities, uniquely tailored to their own strengths and limitations.

Finally, there is a need for ongoing training of prevention researchers across their career. The prevention field is rapidly developing, and new research methodologies must be rapidly disseminated to active researchers. For example new approaches to measurement, data analysis, and new models of intervention are improving the scientific rigor of prevention studies.

Several areas in which there is a particular scarcity of research scientists can be identified. 1) Few researchers are now being trained in the emerging methodological and statistical skills necessary for prevention research. The methodological and statistical challenges of this research are formidable, and new approaches are being developed to meet them. However, graduate programs in core social sciences, such as psychology, are not training sufficient numbers of researchers who are sophisticated in these

approaches. For example, a 1986 survey of graduate programs in psychology reported that only 108 quantitative psychology students were enrolled.[6] Only a small fraction of these have the training to work with interdisciplinary teams to conduct prevention research. 2) There is a paucity of research oriented psychiatrists, currently active in prevention research. For example, across the five NIMH Preventive Intervention Research Centers there is only one research psychiatrist. This lack makes it particularly difficult to integrate a biosocial perspective into the field.

What kinds of National Research Service Awards are needed to meet the training objectives?

The most pressing need is for an increase in the allocation of funds for training in prevention research. The current situation where there are only two funded training programs is a serious threat to the future development of the field. Increased funding is needed for predoctoral, postdoctoral, and continuing training across the career levels.

Currently only one predoctoral fellow is being supported by an NIMH prevention research training grant. Thus, the opportunity is being missed to attract new scientists who initially learn to conceptualize research questions from a prevention perspective.

Postdoctoral training awards provide an excellent opportunity to specialize after receiving a degree in an established discipline. NIMH has had three post-doctoral training programs in prevention research: at Yale,[7] Johns Hopkins University, and Arizona State University.[8] Collectively they have graduated 14 fellows who now hold positions either as Assistant Professors or Research Associates specializing in prevention research. Two of the six fellows from the Arizona State University program are either Principal Investigators or Co-Principal Investigators on NIH or NSF funded prevention studies. Several changes are needed in how these awards are structured to make them more attractive to scholars and to sponsoring institutions. Institutional postdoctoral grants currently do not provide sufficiently high levels of stipends, do not provide a mechanism for funding faculty to work with postdoctoral fellows, and do not provide sufficient funds for fellows to conduct pilot studies to develop their own initial programs of research.

In order to facilitate training of mid-career scientists for prevention research, additional mechanisms are needed. These include the development of prevention research consortia in which investigators from multiple areas could focus on a particular problem in prevention research and mature investigators who are pursuing relevant but slightly peripheral lines of inquiry could be brought into the field. Another mechanism is investigator initiated training awards. An investigator would propose a series of training activities over a 6 to 24 month period, while continuing essentially full-time in their current employment. The activities could include participation in specific workshops or a series of short courses, working in the laboratory of an established researcher, etc. Another mechanism would be an investigator initiated postdoctoral fellowship in which a mature scholar would spend 12 to 24 months working on site with a recognized prevention researcher.

What steps are needed to improve the effectiveness of the NRSA program to recruit minority researchers?

Because ethnic minority and poor people are at high risk for mental health problems, they are often the participants in prevention programs. Consequently, issues of developing culturally appropriate interventions are particularly salient, and it is highly desirable that ethnic minority investigators are trained to conduct such studies. All current NRSA programs for recruitment of minorities into research careers should be expanded to include a special emphasis on prevention. In particular, existing programs that provide prevention programs with additional funds as encouragement to involve minority students and investigators should be strengthened.

NOTES

1. For a copy of the report of the Panel describing the NIMHfunded prevention research training program at Arizona State University, contact Dr. Sandier at Arizona State University, Department of Psychology, Tempe, Arizona, 85287, (602) 965-7420.

2. Institute of Medicine. (1989). *Research on children and adolescents with mental, behavioral, and developmental disorder: Mobilizing a national agenda*. Washington, D. C. : National Academy Press.

3. Costello, E.J. & Shugart, M.A. (1992). Above and below the threshold: Severity of psychiatric symptoms and functional impairment in a pediatric sample. *Pediatrics*, 90, pp. 359-368.

4. Price, R.H., E.L. Cowen, R.P. Lorion, and J. Ramos-McKay. (1988). *Fourteen ounces of prevention: A casebook for practitioners*. American Psychological Association.

5. Muehrer, P. (1990). *Conceptual research models for*

preventing mental disorders. DHHS Publication No. (ADM) 901713.
6. Aiken, L.S., S.G. West, L. Sechrest, and R.R. Reno. (1990). Graduate training in statistics, methodology, and measurement in psychology: A survey of Ph.D. programs in North America. *American Psychologist*, 45, pp. 721-734.
7. The program at Yale was not refunded when the PI moved to another university.
8. The programs at Johns Hopkins and at Arizona State University are affiliated with Preventive Intervention Research Centers.

STATEMENT BY PETER R. SHANK, Ph.D.

Let me first state that I am probably an inappropriate member of this particular panel since I am not the director of a training grant. I have, however, recently been named Associate Dean of Medicine and Biological Sciences at Brown, and as such am directly responsible for the various Ph.D. programs within the Division of Biology and Medicine at Brown as well as the M.D./Ph.D. program. You have actually heard earlier this morning from the current director of one of our training grants, Dr. David Brautigan, speaking on behalf of the American Society for Biochemistry and Molecular Biology, as well as one of the past directors, Dr. Susan Gerbi, speaking on behalf of the American Society of Cell Biology.

My perspective will be from one who was the recipient of both predoctoral and postdoctoral training grant support. In this time of "belt tightening" I think it will be critical for your report to convey the critical nature of NRSA support. I believe one of the major challenges faced today in the United States is the continued development of scientists who are willing to enter academic careers. Those individuals are becoming an "endangered species." With projected faculty retirements by the end of the century approaching 30 percent, the concern is obvious. The teaching/training role of the academic scientist is underappreciated both within the university and in the general public. I was particularly concerned when reading a summary of former Science Advisor Bromley's PCAST report suggesting that universities must be prepared to cut research programs and emphasize teaching. There would appear to be no appreciation of the integral role of research in training scientists within this report. If the academic scientist is unable to maintain a research program, the quality of his teaching/training programs will fall dramatically. This will be followed by a failure to attract top quality scientists into academic research and subsequently by a failure to attract top quality students into graduate education. I believe this process has already begun. When young graduate students see mature and established scientists struggling to maintain minimal research support they say, "No way!" A major force driving top quality students out of academic research is the present level of research funding. While I realize that the NRC has no direct control over the level of research funding, I believe this represents a critical threat to the continuing supply of research scientists.

With regards to improvements in the NRSA program, I would like to separate predoctoral and postdoctoral programs. One of the strengths of the predoctoral training grants at Brown is that they are all interdepartmental, bringing together faculty from many different disciplines. This interdisciplinary approach is a particularly important aspect in such fields as toxicology and environmental science. Similarly our Molecular and Cell Biology & Biochemistry program offers students a broadly-based background in the biological sciences. NRSA support is given only to our best students, and although it represents a minority of our students' funding, it is an essential component of our graduate programs.

With regard to the postdoctoral programs, I believe we need to focus more on the trainee than the sponsor. I believe a strong case can be made for limiting the number of NRSA postdoctorals in any given laboratory (perhaps four). This limitation would tend to encourage the training aspects of the postdoctoral fellowship. One mechanism to accomplish this goal would be to encourage more postdoctoral training grants and less individual awards.

With regards to both women and minorities, I believe early identification is critical. Brown University, under the direction of Dr. James Wyche, runs a number of early identification programs for minority students, and I would like to comment briefly on those.

The underrepresentation of minorities is shocking. Of 24,190 Ph.D.s awarded in 1990 to Americans, 828 went to Blacks, 689 to Hispanics, and 93 to Native Americans. Sadly, these numbers are declining over time. From 1980 to 1990 the number of Ph.D.s increased nationally by 16 percent while those awarded to African Americans declined by 20 percent and for African American males the decline was 50 percent!

This problem is deep-rooted in our society and needs to be addressed far before graduate education. Educational problems for minority students appear in middle years (grades 5-8), and there is substantial difficulty making the transition into high school following eighth grade. Even if the transition is successful, it is most likely into an inner city high school where a diluted version of education is provided. In order to compete academically, such students often require remediation in math and english. If such students do complete the baccalaureate, they are not likely to pursue an academic career since role models and guidance are lacking.

In response to this dilemma a number of colleges and universities have united in a "Leadership Alliance" to "…improve the status of underrepresented students and faculty at various stages of the educational pipeline."[1] The program has four goals including: a kindergarten to grade 12 initiative to raise academic standards; a program to increase minority undergraduate applications by encouraging academically oriented programs in primary, middle, and high school; a program to increase graduate school application by supporting continued academic interest during the undergraduate years; and finally, a program to advance and enrich the development of faculty. I am most familiar with the program to increase graduate student applications by a summer research early identification program. This program brings some 40 students to Brown for a ten week summer research "experience." The students are from predominantly Black schools and participate in a highly structured summer program. I have had such students in the laboratory for the past two years, and one was recently admitted into the Molecular and Cell Biology and Biochemistry Graduate Program at Brown.

My understanding is that most of the funding for this program is from private foundations. My point is that, at least for minorities, we don't need to "reinvent the wheel." There are successful programs for development of minority scientists which should be encouraged and supported.

With regard to assurance of high quality training environments, I believe there are several things which NRSA can provide, including increased funding for seminar programs and research retreats, which would provide relatively inexpensive exposure to real research for the trainees. Furthermore, I think real consideration must be given to limiting the number of trainees per laboratory.

I believe the NRSA training programs are vital for the maintenance of high quality research training within our universities. If we do not continue to pay the price for these programs, we will surely suffer the consequences.

NOTE

1. For a copy of the *Leadership Alliance* Prospectus, contact Dr. Shank, Brown University, School of Medicine, Providence, RI, 02912, 401/863-2765.

STATEMENT BY JUDSON D. SHERIDAN[4]

The University of Missouri-Columbia, a Carnegie Research University, has predoctoral and postdoctoral students holding individual NRSA awards and administers both predoctoral and postdoctoral training grants. We regard these awards as an important source of support for accomplishing our educational mission. These comments both reflect a campus research administration perspective and encapsulate the views of the Principal Investigators of the various training grants on the campus.

From our perspective, a discussion of issues relating to the training of young scientists must be framed in the context of overall funding for biomedical and behavioral research. Sufficient resources for the general support of biomedical and behavioral research are important for implementing and sustaining an effective, overall training strategy. Thus, it is important to continue to press the case for increases in federal support for biomedical and behavioral research. Even in the absence of systematically collected data, anecdotal information regarding the impact of the shortfall in resources on the attractiveness of a career in biomedical research is sufficient to raise genuine concern. Perceptions of insufficient resources clearly are discouraging highly capable people from entering research-oriented track and are even causing some who

[4] Testimony presented by John McCormick, Department of Organic Chemistry, University of Missouri, who co-authored this statement. Please note that Dr. Sheridan is no longer at the University of Missouri-Columbia and is now Vice President for Academic Affairs at the University of Maine. Dr. John McCormick is currently the Interim Vice Provost for Research and Dean of the Graduate School University of Missouri-Columbia.

already have entered training programs to leave for other career directions.

A recommendation logically follows: ensure that training funds are directed to institutions that offer young scientists positive, nurturing environments. These environments should not only have an institutional commitment to supporting research, but also have a strong record of garnering sufficient support from external resources to ensure a focus on and fostering of the intellectual rewards and excitement that derive from involvement in the research enterprise.

Another resource issue is important. The stipends provided by the NRSA training program at both the predoctoral and postdoctoral levels are generally insufficient. As a nation, we will attract our "best and brightest" only by offering stipends that show we value a research track as highly as we value other directions that compete for their professional commitment. If limitations imposed by the funds available for these training programs make it impossible to set competitive stipends, then we recommend that these programs be structured to ensure that by some other mechanism, such as private-sector partnerships, the stipends reach competitive levels. Relying on the simplistic solution of institutional cost-sharing and add-on funds is unrealistic. At the very least, the restrictions regarding the use of other federal funds for institutional cost-sharing should be relaxed.

Beyond the level of resources available within the training environment, another very important aspect is the existence of a critical mass, with respect to both students and faculty. In some cases, special expertise that is particularly appropriate for a training grant may exist at an institution where critical mass is a concern. In such cases, mechanisms, within the institution or among institutions, should be formalized to ensure interactions among sufficient numbers of students and faculty. Furthermore, the need for training young scientists who have multidisciplinary perspectives leads to the desirability of formalizing arrangements for exposure to related disciplines. For example, formal arrangements could be made for interactions between trainees supported by different grants at an institution and for short-term exchanges of trainees with other institutions.

In our view, greater emphasis should be placed on enhancing funding for predoctoral support. The current balance of postdoctoral/predoctoral support has two unfortunate ramifications: (1) there is a relatively large pool of postdoctoral biomedical researchers who move from one temporary appointment to another; and (2) there is a need to more effectively recruit the highest quality students into doctoral programs leading to research careers.

There is another significant result from the current balance of postdoctoral/predoctoral support: the paradoxical position of strong emphasis on the recruiting of underrepresented groups into postdoctoral training programs but insufficient numbers of members of those groups in the predoctoral pools from which the postdocs are to be recruited. Thus, shifting the balance of resources split between postdoctoral and predoctoral training programs more toward the latter also will address another issue: bringing more members of underrepresented groups into the biomedical and behavioral research community.

An emphasis on predoctoral support will dovetail well with the nation's need to attract the "best and brightest" into clinically relevant research. One strategy for stimulating interest of our young scientists in clinically relevant problems would be to structure training programs to expose trainees to clinical areas most closely associated with their particular basic science interests.

We recommend giving greater attention and resources to M.D./Ph.D. programs as a strategy to attract prospective biomedical scientists into research careers. This may be a particularly useful strategy for addressing the need to recruit women and minorities in biomedical and behavioral research careers. Fellowships for M.D./Ph.D. programs and for post-M.D./Ph.D. programs may be considerably more attractive than those that are limited to graduate and post-graduate training.

Direct augmentation of existing individual project grants might also be an effective approach to recruiting members of underrepresented groups into research. On our campus, the National Science Foundation's "Research Experiences for Undergraduates" program has placed Principal Investigators in the dual roles of recruiters and mentors of young scientists. The personal attention that this approach fosters can "make the difference" that directs a bright student into a career in research.

We recommend continuation and even expansion of the recent emphasis on training in professional ethics and scientific conduct. Recent, prolonged efforts to establish uniform guidelines for ethics in research underscore the complexities of establishing codes of behavior. The emergence of a biotechnology-based

industry and the related potential for profit that can spring from a wide variety of research heighten the need for recognition of real and even potential conflicts of interest. We conclude that training programs today must include structured opportunities for young scientists to explore and debate the underlying principles that should guide the ethical decisions that they will need to make.

We recommend building structural linkages between training programs and the private sector, particularly the for-profit private sector. For reasons that relate both to pedagogy and to the need for additional resources, it is important that we find ways to link training programs with the consumers of the educational research enterprise: the pharmaceutical, agricultural, and biotechnology companies that rely both on a source of well-trained scientists and on the research results that are products of the research training environment.

The blossoming biomedical/biotechnology industry in particular has created a new segment of the private sector that has a vested interest in training programs: their content and their vitality as well as the quantity of young scientists produced. Thus, they should be willing to participate both in an advisory capacity and in the role of resource provider.

There exist good models for linking training with the private sector in disciplines such as engineering and chemistry. Experience in these areas offers opportunities to learn what works and what doesn't. One suggestion that we find appealing is the establishment of private sector intern programs at various stages in the educational process. Very early in the educational process, such programs could be effective strategy for recruiting young scientists. Targeted correctly, they could assist in the special recruitment efforts directed toward underrepresented groups. Internships at later stages in the training could provide trainees with an important perspective that would not likely be gained within an academic institution, with access to alternative laboratory approaches, and with funds for support that could markedly enhance the overall training experience. At the same time, these programs would offer the for-profit private sector an opportunity to help ensure an adequate supply of appropriately trained scientists and, on an individual basis, a head start on recruiting. Thus, we see adequate incentive from both sides to make this an effective approach.

STATEMENT BY HERBERT B. SILBER, Ph.D.

I believe that as presently administered, the National Research Service Awards fund some of the best and brightest young people committed to a scientific career. They graduate from outstanding universities and they sit at the top of their class. These students go to major Ph.D. granting universities. They are the cream of the crop. I can support the awarding of additional grants, because these students have the potential to be motivated and successful biomedical researchers. However, other initiatives are necessary to radically increase the numbers of graduate students in the biomedical sciences. The representatives from the major Ph.D.-granting universities will make suggestions about how to improve graduate educational opportunities. My training and interests lie with precollege and undergraduates, especially to reach out to economically disadvantaged and minority students who are not presently reached. I am making suggestions in the following areas.

1. Reach out to minority students at both minority and majority institutions.
2. Get undergraduates involved in undergraduate research to enhance their understanding of what a graduate program will involve.
3. Reach below the college level to encourage students into research as high school students, and even more importantly, we must stop turning off our elementary school teachers to science.

The question posed by this group is how to enlarge the numbers of high quality students in the biomedical and behavioral sciences. The students who may be missed are those who have the ability to make successful contributions to science, but because of many factors, often not related to academic ability, will not receive these awards. My favorite student is one who is bright and will be successful, but does not yet know it. I am an NIH Minority Access to Research Careers (MARC) Program Director at San Jose State University (SJSU), and most of my MARC students are in this category. I am also a faculty research participant in the NIH Minority Biomedical Research Support Program. These high ability minority students, even those with very high grade points, have not received a lot of

positive strokes in public school or college. Even in the 1980s and 1990s, some were asked by high school teachers and counselors why they wanted science and mathematics courses, since they would not need them. When they get to SJSU and into the MARC program I can help them get them into good universities with their own financial support. However, many of them do not do well on GRE exams and they can get discouraged. I meet with these students each week to encourage them and help them through their rough spots. However, how many high-ability students, both majority and minority, do we miss because they do not get this attention? How many MARC students received NRC Awards? How many more will go on to be successful scientists? At SJSU we deal with first generation college students, both majority and minority students, who come here because it is affordable. There are many public institutions like ours that have high ability students (our best are as good as those anywhere, we just do not have as many of them as a Stanford, UC Berkeley, or other high quality institution has). Many of these students who could become good scientists will not because they do not know the opportunities that are out there. When I invite successful minority scientists to speak to our MARC students, I have them talk about how they decided to become a scientist. Every speaker has said that a single individual (some majorities, some minorities) noticed them and gave them crucial encouragement. For some of these successful individuals, they did not yet have the highest grades, but their aspirations changed. Perhaps the NRC awards could recognize some of these qualities and do the same. I am not suggesting that some awards be reserved for minority students, but perhaps in judging achievement we look beyond where the students got their degree and we look at what they have achieved.

If you want to get an undergraduate into a Ph.D. program, I believe the best way is to get them involved is undergraduate research. I have had continual support for undergraduate research, even though I have never taught in a Ph.D. granting institution. I have been very careful to have both majority and minority students working together. I am funded by minority student grants, but I also have other funds for any students, and my group has a mixture of majority and minority students, both male and female. The students pick their own leaders in the group, and often it is the minority students. Undergraduates have presented talks at national meetings and they have been coauthors on publications. Many of the grants for undergraduate research are small, but highly effective. Perhaps the NRC might want to initiate a program of small grants for undergraduates, either by having the students apply or by having a faculty member/student joint proposal (with a page limit that is reasonable, 5-10 pages, plus CV's). If the concern would be that only students from the top universities will get these, perhaps one of the criteria for review may be how the project includes minorities and women. We need to reach women and minorities who attend majority institutions. Remember, both NSF and NIH have programs for research grants at non-Ph.D. institutions. The key to my success with undergraduates is to find the talented ones early (freshman/sophomore years) and to get them involved in undergraduate research. It takes a lot of my time early on, and is not productive. However, by the time they are juniors or seniors I have excellent research students. This approach applies to all students, but may be even more important for engaging minority students to think about a scientific career. In my early participation in the MARC program, I was opposed to the MARC requirement that the students go away for a summer after their junior year. I thought it took them away from my research for their most productive summer. However, the students come back with significant maturity, confidence, research ability, and the desire to pursue advanced training. Therefore, I would like to propose new NRC Awards for undergraduate research at any university where undergraduate research is strongly encouraged. I would require that the students go to a Ph.D. granting institution for the summer after their junior year, with the award paying the student's stipend, travel and living expenses for the summer. The host institution should also receive a small allowance for supplies. Many schools have these programs, especially for minority students (MARC students generally have an easy time getting summer support). It is especially important that these opportunities be made available to minority students at majority institutions, where they often are not encouraged to get involved in undergraduate research.

I have run an ACS Project SEED Program for high school students. One of the guidelines is to find students who may not be the best in their class, since the best seem to receive all of the awards. We are encouraged to look for students who will benefit from a summer in a laboratory working on a small research project. I have been on a panel that just awarded three scholarships to graduates of the SEED program, and

one to two summers of research in a university or government or industrial laboratory made a big difference in their aspirations. Some opted to leave science, but most decided to become scientists. We could have given the scholarships to almost any of the more than 100 applicants. Perhaps the NRC may want to consider some undergraduate scholarships for high potential high school students who have participated in programs at colleges before graduation from high school.

The most significant challenge for maintaining an adequate supply of qualified biomedical scientists is to reverse the view that we (the teachers) have managed to communicate a fear of science, coupled with the ability to make science appear difficult and, even worse, dull. This needlessly decimates the pipeline. The elementary school teachers we turn out do not have a strong science program. Since many of our beginning science courses are used to weed out students, they learn to fear science and pass this fear on to their own students. In chemistry, we tend to emphasize theoretical fundamentals in the beginning courses and often do not teach anything about the excitement of doing science. For example, we insist that students memorize “essential facts”, such as quantum numbers, but we rarely get to talk about new and exciting developments, such as MRI, high temperature superconductors, Buckminsterfullerenes, etc. Many of our first year laboratory experiments are “cookbook” and students leave with the wrong attitudes. We often succeed in turning off the future teachers and, in addition, we also turn off those students bright enough to succeed in science. If we can modify our beginning science courses to motivate students to become interested in science, the pipeline problem can be addressed. One way I attempt to do this is to take on freshman science students into my undergraduate research group (and I have had high school students from the American Chemical Society Project SEED (Summer Educational Experience for the Disadvantaged) and high school teachers from the Research Corporation Partners in Science Program). Students who get involved in doing science early often either become scientists or lose their fear of science.

Insufficient funds are available to solve all of the problems. There are two fronts that the NRSA program could work on. First, more high school teachers and students should be exposed to science. Either new programs should be initiated, or better yet, find the small successful programs and pool resources to expand the scope. Three programs have already been mentioned in this letter (ACS Project SEED for economically disadvantaged students, Research Corporation Partners in Science, NIGMS MARC). Each is doing a good job, but needs to be expanded to encompass more teachers and students. We do not need to reinvent the wheel, maybe just give it some more grease. If a mechanism could be found just to get more university faculty to interact with elementary, middle school, and high school teachers, we could remove some of the barriers for students to get involved in science.

If these awards are to reach out to students at many different kinds of institutions, it is critical that proposal review contain representatives from the minority institutions, urban comprehensive universities, and the well-known private liberal arts colleges, as well as first-rate scientists from prestigious institutions. By opening up the review process, a wider range of students may be recognized. The NRC already helps review special grants for minority students. We need expansion of these programs as well as the extension to other student categories as mentioned in this letter.

STATEMENT BY HAROLD SLAVKIN, D.D.S.

I am Professor of Craniofacial Molecular Biology at the School of Dentistry of the University of Southern California. I come here today as President of the American Association for Dental Research, representing 4,500 professionals involved in oral health research throughout the United States. Our Association promotes research to improve oral health and also fosters dissemination of scientific advances relevant to oral health. My Association has already submitted a statement to the Committee and has given its views on the four questions raised by your Committee. My remarks today are in addition to our initial statement. I also speak on behalf of the American Association of Dental Schools, which represents all of the dental schools in the United States, as well as advanced education, hospital, and allied dental education programs. It is within these institutions that researchers are trained and the majority of dental research conducted. From the perspective of oral health research needs, we believe that in order to ensure a viable scientific effort in oral, dental, and craniofacial health in the coming decade, we need a sufficient number of

well-educated and well-trained dental scientists in the most relevant areas of basic and clinical research related to oral, dental, and craniofacial diseases.

I have been an independent investigator for 25 years and have served as principal investigator on several NIH-supported training grants in cellular, molecular, and craniofacial biology designed to improve the scientific work force within oral, dental and craniofacial research. My own experience illustrates the wisdom of federally-sponsored research training opportunities specifically for dentists seeking additional education and training to become biomedical research scientists. As a sophomore dental student, I became engaged in biomedical research with anatomy, biochemistry, and oral surgery faculty members and remained involved for the remaining three years of my dental education. My mentors were Lucien Bavetta and Marsh Robinson. I was the first dental student at the University of Southern California ever to pursue post-doctoral training in biomedical research (that was as of 1965). Curiously, at that time our USC School of Dentistry had essentially one NIH-sponsored grant and an academic culture which did not include scientific research; the mandate of the school at that time, like that of so many Schools of Dentistry and Medicine receiving federally-derived capitation funds, was to focus on producing large numbers of clinically-trained practitioners. Biomedical research was not mainstream, nor were the cultural derivatives of inquiry-based, problem-solving learning. Through National Institute of Dental Research (NIDR)-supported training programs, either leading to the Ph.D. in basic or behavioral science, or through post-doctoral training experiences, a small cadre of individuals was educated and trained to provide the core of the American dental research community. The yield from the Federal investment in dental intellectual capital has been remarkable. Dental scientists trained through these mechanisms now populate a number of outstanding Schools of Dentistry and Research Centers in the extramural community and also provide the leadership for the Intramural Research Program of the National Institute of Dental Research. Our current USC School of Dentistry now ranks 9th in the nation in terms of NIDR-supported biomedical research, through the efforts of dental faculty trained through the various predoctoral, post-doctoral, and research career development mechanisms.

It became readily apparent--in the 1960s, 1970s, and unfortunately, now--that graduates from most American dental schools require extensive additional education and training after dental school if they are to become competitive within the larger American and international biomedical research communities. The fruits of these fine training programs could subsequently be assessed in terms of trainees gaining academic positions in basic science and clinical science departments, gaining extramural grant support through peer-review processes, publishing their research findings in excellent peer-reviewed scientific journals, and fostering improvements in the scientific culture at increased numbers of dental schools. Graduate dentists with advanced education and training began to publish in major scientific journals (*PNAS, J Biol Chem, Immunology, Microbiology, Neurosciences, Developmental Biology, Materials Sciences, Anthropology, Behavioral Sciences, JDR,* etc.), and began to serve on the editorial boards of major scientific journals.

The wisdom of that time was to create a custom program for graduate dentists to produce a modest number of well-educated and well-trained independent biomedical research scientists who could have a direct impact on the educational and scientific culture of dental education in America. That need of the late 1960s remains today. Whereas a number of American dental schools truly reflect the highest standards in the biomedical sciences, far too many have yet to obtain scientifically-trained manpower sufficient to meet the challenges and opportunities of the 1990s. As a consequence, five American dental schools have been forced to close, the major reason being a deficit in the biomedical research activity of the faculty. The unique need for dental education in this country is a federally-supported mechanism to continue to educate and train graduate dentists for careers in biomedical and behavioral basic and clinical science.

However, to achieve a reasonable and continuing number of dental biomedical research scientists is a complex challenge. It is readily apparent to all of us that there is a paucity of historically underrepresented minorities in the biomedical and behavioral research work force. Several variables--such as declining parent involvement, school readiness of the child, the quality of administrators and teachers in K-12 education, declines in federal and state standards for academic performance, the challenges of multicultural diversity as readily apparent in California and other major states, along with increased violence in our urban settings--all reflect significant declines in American secondary education. NSF studies indicate that children can be

identified as competent for science and mathematics by the fourth grade. Numerous national studies indicate that middle school algebra is often the gatekeeper for who will become college-bound and science- and math-literate. Too few Americans graduate from high school with scientific, mathematics, and cultural literacy. Of course, the pool of individuals who will seek careers in dentistry falls within our national pool of high school graduates who are prepared for college and who possess a science and math background sufficient to pursue careers in biomedical sciences. That pool is diminishing.

All health-science-based professions are discovering that home-grown American children are not being nurtured and prepared for careers in biomedical and behavioral science. Our nation is still at risk ten years after the Carnegie Report! Of the high school graduates from American secondary schools, very few are formally prepared. Moreover, of the annual 17 percent of all freshman college students who declare a scienceor math-based major (such as engineering, premed, predent, prepharmacy, chemistry, physics, etc.), nearly one-half of these students change their majors out of science by their second year of college. Therefore, the projected pool of science-and math-prepared undergraduates who could consider pursuit of professional or graduate school education is remarkably small as we ponder who will serve in the American biomedical and behavioral research work force in the 21st Century. Our nation has a challenge that includes both precollege science and math preparation as well as undergraduate university science and math pedagogy. The Committee is encouraged to look at the sequence and scope of the American educational pipeline in order to ensure increased representation of women and minorities in the biomedical and behavioral sciences. We need national “mentor programs” to couple young children, especially females and historically underrepresented minorities, with established biomedical and behavioral research scientists as role models in order to nurture the next generations. Further, we need a national coalition among federal agencies (within the Departments of Labor, Education, Energy, Defense, Health & Human Services, including the NIH and the NSF), the National Academy of Sciences, the private industry sector, and state and local government to analyze “our nation at risk” in terms of early childhood, preschool, K-12, and college learning in the sciences with implications for the pool of future biomedical and behavioral research personnel.

Finally, I wish to close my remarks with several specific recommendations essential for our dental research community:

First, the number of training opportunities and the research funding levels must be coordinated to provide sufficient stability for developing clinical biomedical and behavioral research scientists capable of addressing the broadened oral health research agenda. Unlike medicine, the NIDR is essentially the only sponsor for dental research training through its NRSA post-doctoral programs. Training efforts must be closely linked to opportunities for research funding, federal and otherwise.

Second, because of the broad scope of oral health research, personnel of all types need to be considered and a multidisciplinary approach adopted, with an increased emphasis on clinical research.

Third, particular efforts should be made to enhance the stipend levels for individuals seeking careers in clinical research. The current dental degree graduate from an American dental school is often in debt for $55,000, which is 20 percent more than for physicians. We need a process either to forgive student loans for those individuals entering careers in clinical research, or to increase the stipend level sufficient to provide the individual with the means to pay off loans and pursue his/her career development. A National Health Service Program to permit professional school graduates to repay educational loans by serving as post-doctoral fellows or the establishment of a Dental Scientist Training Program (DSTP), analogous to NIH’s current MSTP program is an additional mechanism to be explored for removing financial barriers to research careers.

Fourth, NRSA policies should be changed to (a) raise the level of support for investigators, (b) lengthen the time of service (i.e., 3 years for a graduate dentist to earn a Ph.D. is not sufficient), and (c) remove pay-back obstacles. NRSA policies should serve to induce individuals to pursue this career objective and not serve as an obstacle. The most significant challenge we face in maintaining a critical supply of qualified dental research scientists is the ability to break through the financial barriers which inhibit even the most motivated young people to pursue a career in dental research.

Fifth, it is important that minorities and women are adequately represented in the research fields. All NRSA training programs should require defined “outreach” programs to the K-12 educational

community to celebrate science and mathematics and to encourage very young children to begin to focus on careers in science and mathematics, with particular emphasis upon biomedical and behavioral research. Local experiences in Los Angeles between our USC Schools of Dentistry, Medicine, Nursing, and Pharmacy with the K-12 Los Angeles Unified School District have been extremely rewarding. The creation of a new high school dedicated to careers in the health sciences (Francisco Bravo Medical Magnet) adjacent to a teaching hospital environment provides an outstanding experiment for secondary school recruitment of historically underrepresented minorities into the health sciences at our university. NRSA programs forming partnerships with the NIH-sponsored Minority Access to Research Careers (MARC) as well as the NIH Minority Supplement Programs give "value added" opportunities to identify and nurture future scientists from a multicultural society. New coalitions between university-based professionals supported by NIH or NSF funds and K-6 teachers provide additional opportunities to nurture science and mathematics in the next generation. There are several successful models-for example, the efforts of Bruce Alberts, the new director of the National Academy of Sciences, linking the University of California-San Francisco health sciences faculty with elementary school teachers (K-6) from the San Francisco public schools, and our own efforts in Los Angeles to link the USC Health Sciences with 24 inner-city elementary schools through an NSF-sponsored program called "PRAXIS."

Finally, NRSA trainees should be educated and provided with skills for multidisciplinary research, collaborative research, and often research which engages team-based expertise from university, federal, and private industry laboratories. We have every reason to believe that the ideal preparation for the future of biomedical and behavioral research personnel is to equip people with the skills to address changing challenges in a rapidly changing environment.

Your Committee has the responsibility to outline the research personnel needed in biomedical and behavioral research, including specific recommendations for certain disciplines including dentistry. My Association would welcome a specific report for oral health personnel and are prepared to work with your Committee to achieve this. The 1985 report was extremely helpful in advising Congress and in planning future manpower requirements.

This Committee has been the instrument for long-range investment in the intellectual capital of dental research. Your efforts can continue to provide the essential research work force required for the unique challenges in dental education and oral health research. I urge you to support the continued opportunities for dental graduates to pursue research careers in the biomedical and behavioral sciences.

STATEMENT BY ORA A. WEISZ

As a very grateful recipient of an NRSA postdoctoral fellowship due to expire this July, I can honestly say that my NRSA has provided me with scientific independence and flexibility, and has greatly enhanced my postdoctoral experience at the Johns Hopkins School of Medicine. I would like to focus my comments to the Committee towards two questions. "How can we recruit today's young people, and minorities in particular, to scientific careers?" This must involve a concentrated effort to increase the level of interest in science starting in elementary school. The second question is, "What can the NRSA program do achieve this goal?" Do everything possible to stabilize young researchers in the form of training grants and employment opportunities.

I was not lured to basic research by visions of fame or fortune. I love my work and would not willingly trade my profession for another. Furthermore, the hours and working conditions that most of my peers and superiors put up with suggests to me that they must feel the same way. Therefore, I would argue that the critical step in maintaining an adequate supply of investigators is to recruit them early: once these people are hooked, chances are few will leave by choice.

The most obvious way to interest children in science is to improve science education. Recruiting youngsters, and especially women and minorities, into science must begin at an early age: no one will elect to take first-year physics in college unless they already have a reason to believe they might like it. Frankly, I was terminally bored in most of my elementary and high school science classes--I pursued a career in research only because both of my parents are scientists. From them, I learned that basic research bore little resemblance to my school experiences. I frequently felt that my elementary school teachers themselves disliked

teaching science: in retrospect I can only assume that their teachers were much like mine.

An increase in the science education budget of public schools, with funds earmarked for experimental supplies and field trips, would help to spark children's interest in science. Students in metropolitan areas who show an early interest in science should have access to magnet schools which emphasize scientific training. These schools should have well-equipped laboratories, and classes should be taught by teachers who like science. Such schools would undoubtedly provide a healthy return on their investment. Furthermore, bowing to the irrevocable fact that children today are hooked on television, a children's television show focused on science (with a racially balanced cast) might also help interest youngsters in science.

This brings me to the second question: what can the NRSA do to help? The NRSA arrives too late to play a critical role in influencing children directly. However, the NRSA program could sponsor short-term fellowships for science teachers to spend semesters or summers doing research in a laboratory. Equally effective, NRSA fellowships could sponsor scienceoriented undergraduate or graduate students who wish to teach elementary or high school students. Similar types of programs are already being administered by some private scientific organizations. All of these functions should fall under the stated goal of the NRSA Program, which is to "increase the capability of the …NIH…to carry out their responsibility of maintaining a superior national program of research...."

The NRSA program could encourage women and minorities interested in science by providing well-paid summer research fellowships for undergraduates. These should include salary, traveling expenses, and a small stipend. In addition, the NRSA might sponsor fellowships in areas peripheral to science, such as science writing and reporting. Recruitment of talented women and minorities to serve as role models in these areas may eventually help to stimulate public interest in science and enhance its status as a profession.

Finally, I would like to address a more general issue that the NRSA should tackle. This is the lack of funding for postdocs beyond their third year. It is not unusual now to do a second postdoc before looking for permanent employment. While one could argue that these researchers no longer need funds for "training", the loss of independence that comes with the termination of an NRSA is demoralizing. An NRSA program to fund senior postdocs would reinforce the government's commitment to support new recruits and would be much welcomed by those of us who have already chosen basic research as a profession.

STATEMENT BY MIYUKI YAMAGUCHI

I am a graduate student in biochemistry. Despite many obstacles, I have chosen science as a career and as of yet, I do not regret this decision. But unlike myself, I have seen many of my fellow students not only shun this career path, but science in general. Their perception of science is often limited to poorly taught high school level courses and the images portrayed by the media. When I talk of science to friends and family, I often observe blank stares, wandering eyes, and an abrupt change of conversation to sports or the weather. My friends outside of science not only have no understanding of what I do, but often refuse to listen, claiming to have no interest in science. Their lack of background is understandable, but their adamant refusal of and complete mental block to science comes as a shock. This perception continues and pervades the decision of many college students to not pursue a science career, with the end result being an overall decrease of well-qualified candidates applying to graduate schools. The few who do choose science as a career often pursue this as a path by default, being left with no alternative after medical school rejections or for lack of any other potential career. This underappreciation and misunderstanding of science in general is beginning to hinder not only the research in this country, but also major issues outside of science, such as health care and the environment. I fear that this trend generated by my peers may vastly affect the quality of research in this country and, furthermore, deepen the general public's ignorance of science. I feel that it is our responsibility as researchers today to reverse this direction so that the scientific potential of this country is neither wasted nor ignored.

From my own observations, I believe that there are four basic reasons why bright young people are discouraged from science today:

(i) inadequate early education in science
(ii) limited financial reward from a career in science
(iii) lack of research funding
(iv) the image of science as being boring, incomprehensible and/or "not cool"

Unfortunately, I alone cannot reform an entire national education system or provide the financial resources for salaries and funding in research. Yet I, as an individual, am willing and capable of sharing my experiences with others, with the message that science can be interesting, challenging, and just plain "fun", in hopes of altering the future perception of science and expanding science education beyond the classroom. But addressing this problem at the college and graduate school level is futile, for the mindsets and perceptions of most students are firmly set at this age. The problems are deep-rooted and stem from early in the education process. Thus the main focus of our attention should be towards the education of the children, for they are a huge undeveloped intellectual resource, which has continually been ignored in this country.

From my experience, education in science has often been limited by outdated textbooks and poorly informed teachers. As a result, early in the classroom experience, the perception of science as being incomprehensible and dull is born and is further perpetuated by the media later in adulthood. As we all know, science is not the memorization of random facts, but an approach to solving problems. It is this active participation in science along with an appreciation of the subject and its impact on life that makes science truly fascinating. Unfortunately, many young people today never connect their studies in the classroom to application in the real world. I am a perfect example of this. Pursuing a Ph.D. never crossed my mind until my first biochemistry class where I learned that a disease can be linked to a non-functioning enzyme. This was a turning point in my life, giving me future direction for my career, but unfortunately that moment was late in my education. In my opinion, the understanding of science and its relevance to the natural world about us is the major link absent in the education of our children. I believe that students like myself are able to bridge this gap between theory and application, and present it at a level which a young student can appreciate. I propose that graduate students and fellows be granted the opportunity to supplement early science education, by sharing their knowledge, experience, and activities with young students.

Most children have the natural intuition and curiosity required for science. In order for these traits to surface, they need to be stimulated and motivated by interesting information from the viewpoint of a child, presented by enthusiastic teachers who can adequately show them how this information can be used in the world around them. This presentation of information should be at various levels from basic theory to application to career opportunities, so in the end children can eventually realize what types of academic courses are required for pursuing a particular career. In order for this to be successful, a coordinated effort among the local education systems, academia, and industry is necessary. The teachers should lay the initial foundation of information for the children. The graduate student or fellow can then further develop that information, such that the child can learn to apply or relate the ideas of his/her own environment. Industry and academia should provide interesting careers in the real world. Thus, the main role of the graduate student/postdoctoral fellow would be:

(i) to bring new information typically unavailable to young students and present it at a level that the child can understand and appreciate
(ii) demonstrate the application and relevance of this new information to the child's environment
(iii) show the potential and power of science, and its past and possible future impacts on society
(iv) update the teachers' education of science, so that they have a thorough understanding of the basics and an awareness of recent relevant findings

Unfortunately, no matter how interesting the topic, a one-day presentation of science is not sufficient in developing the potential of young students. Two other factors are equally, if not more, important:

(i) an active participation in science, where the learned information is applied
(ii) the intellectual activity and active participation must develop over time, such that the self-esteem and self-confidence of the child in science is nurtured

There are various methods of incorporating these factors into early education. One is through the formation of science clubs, with the help and guidance of not only graduate students and post-doctoral fellows, but the scientists and researchers in industry. Another is through summer science programs, where kids can actively participate without the burden of other school

activities. Many programs have already been created, echoing the problems and potential solutions presented here. I believe that these programs can greatly benefit from the experience, knowledge, and enthusiasm of graduate students and fellows. This type of effort requires very little financial support and may be as simple as directing attention to opportunities in these types of programs on the first day of a graduate student's career. With more effort and energy, new programs can be created through the graduate student community to generate interest in and awareness of science among young people.

These factors mentioned above are especially crucial to those of disadvantaged and/or minority backgrounds. Recruitment of minorities should not necessarily be at the graduate school level, where larger stipends are often used as a tool to attract candidates to a very small minority applicant pool. Throwing money at a fully-developed problem is not always the best solution.

Considering the above factors, along with encouragement and guidance in early education, should allow students of all backgrounds to realize their own potential for science and later for becoming qualified researchers. Programs targeted and designed for particular backgrounds and/or disadvantages would more effectively attack the root of the problem involving recruitment of minorities and women.

The observations and advice I have offered here are based on my own limited perceptions of my environment. I have no statistics to verify my observations. But I have noted too many instances where my peers have displayed a lack of appreciation of science and research, such that it has instilled a growing fear in me that the future research potential may be at stake in this country. This ignorance of science cannot be tolerated if it interferes with a child's desire to learn. Along these terms, improving education is crucial, but as a graduate student, I have limited power in influencing the policy of science education in this country. I would like to take action on this problem, for I strongly support science and research, not because it is my future career, but because I believe it is the backbone for the advancement of a society. This fear and ignorance of science should be eradicated for it is equivalent to the fear of understanding our natural world. There is too much this world offers to teach us to allow this fear to inhibit the future directions of our society.